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Advances in Web Based Learning – ICWL 2009

8th International Conference
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Volume Editors

Marc Spaniol
Max-Planck-Institut für Informatik
Department D5: Databases and Information Systems
Campus E1 4, 66123 Saarbrücken, Germany
E-mail: mspaniol@mpi-inf.mpg.de

Qing Li
City University of Hong Kong
Department of Computer Science
Tat Chee Avenue, Kowloon, Hong Kong, China
E-mail: itqli@cityu.hk.edu

Ralf Klamma
RWTH Aachen
Lehrstuhl Informatik 5
Ahornstr. 55, 52056, Aachen, Germany
E-mail: klamma@dbis.rwth-aachen.de

Rynson W.H. Lau
City University of Hong Kong
Department of Computer Science
Tat Chee Avenue, Kowloon, Hong Kong, China
E-mail: rynson@cs.cityu.edu.hk

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Preface

To praise oneself is sure a fault; yet who
That does aught good escapes it? If he feigns
In those his words no whit, and all be true,
The good for ever good remains.

Book of Ill Humor
West-Eastern Divan, by Johann Wolfgang von Goethe
(Translation by Edward Dowden)

ICWL is an annual international conference series on Web-based learning that has so far been held in Asia, Australia and Europe. This series represents the cooperation of European and Asian researchers to advance the field of Web-based learning. Numerous joint research papers and joint projects have emerged from the successful track record of ICWL. We have chosen a short quotation of the West-Eastern Divan by Johann Wolfgang von Goethe to express the spirit of the conference series establishing a stable bridge of research between the continents.

This year's conference location was a perfect symbol of this spirit. The 8th ICWL 2009 was held in Germany's westernmost located and truly European city Aachen. At the borders with Belgium and The Netherlands, it is within convenient reach of European centers like Brussels, Cologne, Paris and London. In its history, Aachen was the capital of Charlemagne, perhaps the first European emperor, and the place of coronation for the medieval Holy Roman Emperors following him. From its beginnings as a bathing resort of hot springs established since Roman times, Aachen was also a meeting point of the East and the West. As a city of pilgrimage, knowledge from the East found its way on the ancient routes and Western ideas traveled in the other direction. Exactly these old traditions are revitalized in papers collected in this proceedings volume.

Accordingly, authors that submitted work to the ICWL 2009 conference came from more than 30 countries with remarkably many submissions from across Europe. Altogether, we received a total of 106 valid submissions. After a rigorous reviewing process, we decided to accept a total of 38 papers as full papers, representing an acceptance rate of 36%. In addition, we accepted another 14 papers as short papers. Moreover, we included three invited papers of renowned researchers into this conference proceedings volume. As a novelty, we had four co-located workshops with the conference. Having immediately attracted four workshops we interpreted this as an indicator of the significance and visibility of this conference series within the Web-based learning community.

ICWL 2009 was jointly organized by the Hong Kong Web Society, RWTH Aachen University, and Max Planck Institute for Computer Science.

August 2009

Marc Spaniol
Qing Li
Ralf Klamma
Rynson W.H. Lau

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Invited Papers

Refereed Papers

Personal Services: Debating the Wisdom of Personalisation

Helen Ashman[1], Tim Brailsford[2], and Peter Brusilovsky[3]

[1] WebTech and Security Lab, University of South Australia
helen.ashman@unisa.edu.au
[2] School of Computer Science, University of Nottingham
tjb@cs.nott.ac.uk
[3] School of Information Sciences, University of Pittsburgh
peterb@mail.sis.pitt.edu

Abstract. Personalisation has been seen as the answer to the vast quantity of information now available digitally. Information is tailored to meet each user's apparent needs, whether making use of Web-based learning materials, purchasing from online sites, accessing entertainment products or any other potentially-personalisable facility. Yet before rushing headlong into personalising everything, including online learning systems, we need to consider the threats posed by the capture of so much data about individuals, the implications of personalised information delivery, and whether the benefits of personalisation justify the costs. In this paper, we look at both the issues and benefits of personalisation, and consider how to steer our way to a safe and valuable use of personalisation.

Keywords: personalisation, adaptive hypermedia.

1 Introduction

Technologies are not inherently good or bad, but are only good or bad depending on how they are used. Obvious examples include nuclear power and television, but even technologies we generally think of as "good" can be misused, such as medical advances being exploited for biological warfare.

Personalisation is one such technology whose use determines its value. Its aim is to identify and promote information most suited to the user's current needs, and is generally aimed at tailoring information and presentation to the user, rather than to the context (such as device). It does this by keeping information about the user in a user model, either persistently (where the user's details can be retrieved from previous sessions) or pseudonymously (in short-term user models where details are collected during a session but cannot be corroborated with prior sessions). This information is often voluntarily entered by the user but also is very frequently inferred from their interaction with the site, not necessarily with their explicit permission. This information includes not just personal details such as name or last item viewed, but also behavioural data, such as sequences of pages visited and purchase history.

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However user models are not necessarily provided for the benefit of the user, but often aid the personalised site in its marketing. This is evident in the use of commercial recommender systems whose primary aim is to encourage the user to purchase more items by exposing them to items that other users bought, based on similar purchasing or viewing patterns.

Personalisation appears in different application areas, with e-learning one of its early application areas and the favoured demonstrator for adaptive hypermedia systems. In such systems, the benefit to the user was a priority, based on a reduction in personal interaction with the teacher. Adaptive hypermedia systems could provide specific, personalised feedback at a time when class sizes are growing and distance learning becoming more commonplace.

However e-learning personalisation systems are largely experimental, and have not achieved much market penetration or influence on mainstream teaching and learning. This is especially so when compared to e-commerce personalisation. Recommender systems are one key example of personalisation in e-commerce, very well-developed and evidently very successful, judging by their continuing development.

This paper is presented in the classical debating style: the *thesis* in section 2, where we propose that personalisation is harmful and detrimental to users and the community, the *antithesis* in section 3 where we propose that personalisation has so many benefits we cannot afford to ignore this bright new technology, and finally the *synthesis* in section 4 where we draw together the arguments and point to a middle way of sensible, considered application of personalisation.

2 Thesis - Personalisation Considered Harmful

The thesis states that personalisation is dangerous and harmful for a number of reasons: it is detrimental to security and individual privacy; it is an inherently unreliable; it has various potentially negative cognitive implications; and it creates inconsistency and disparity in outputs which can lead to an inequality of opportunity. Finally, it has no place in e-learning, its value failing to be manifested in user trials.

2.1 Security and Data Privacy

One problem that is only going to get more challenging is what happens with the increasing amount of personal data accumulating in all those user models.

Consider privacy and personal data ownership. Who keeps and owns the record of personal preferences? Can we see our own records and what right of reply do we have if that information is wrong (e.g. hypertext visionary Ted Nelson had difficulty convincing the Wikipedia moderators of his true birthdate [19])? What happens if it is released either deliberately, such as with the AOL500k query logs [1], or is breached by hackers? While these might not seem of immediate relevance to student user models, they all have consequences for students and for any personalisation that relies on user models.

Other than the obvious concerns about confidentiality, there are more insidious issues at stake. Think about how personalisation systems make assumptions and inferences about the user, what Brusilovsky called "implicit" user model data [5] derived by recording the user's behaviour and inferring characteristics about them. These assumptions can be particularly worrisome if the user does not know the data is being collected, how accurate they are or what inferences are being made on that basis (buying a child's toy doesn't mean the user has children). Too often, there is no transparency about the inferencing rules, which may themselves be flawed.

There are implications of such inferencing rules, in particular, political and social implications, whether correct or not. This could be especially in a changing political climate. As noted in [12]: "*A particularly worrying example is that of the Morgan Stanley Dean Witter bank who "collect", among other things, details about an individual's race, religious beliefs, sexual preferences, union membership, etc. As this information is never required as part of the credit application procedures, it is most likely inferred by analysing the individual's subsequent spending pattern. This is similar to the way supermarket chains infer such things as marital status, number and age of dependents etc. using their "loyalty cards" to analyse purchasing patterns. Morgan Stanley Dean Witter also claim the right to disseminate this information*".

This exemplifies the real concern about privacy in the 21st century. 1984's Big Brother will be in the hands of corporations, not the government [12]. For students, it is generally their educational institution that holds their student records, but with educational IT increasingly being outsourced to private enterprise, student user models will end up in corporate hands, perhaps even deemed to be owned by the company providing the personalised resources. Users are becoming wary of providing data to unknown sites or for unknown purposes, and as Nielsen says "*A lot of privacy concerns have to be addressed before users will be willing to give out as much personal info as is necessary for good personalization*" [20].

A related side-effect of personalisation is that it creates associations, even where not explicit, generally by focusing objects implicitly around an entity, such as text alerts to a mobile phone, or purchase interests in “my ebay”. All these things may have little importance individually, but taken together can be used to build up a “big picture” of a person and their activity. In a time of political unrest and fear, even student records can contribute towards a case against an individual, as shown by McCarthyism in the 1950s in the USA.

2.2 Reliability

Exactly how personalisation works varies wildly between different implementations. However, most of these involve the adaptation of the user experience for the individual user. This may consist of the adaption of the presentation of content, or the navigation within that content. In order to do this, information about the user is gathered by the system and a profile is constructed from a record of the users behaviour. The generic template for constructing this profile is the “user model”, which describes various features of the user, and a user model of some type is at the heart of all automated personalisation systems. There are many approaches to user modelling, but they all work by categorising the users’ knowledge, interests, goals, background and individual traits in some way [8]. Many of these techniques are highly regarded by personalisation practitioners and they have been demonstrated to work well under many conditions. However, none of them is perfect. People are extremely complex, and any attempt to model human behaviour is always likely to be somewhat approximate. Any automated personalisation system can only be as good as its underpinning user model, and any failure of the user model can have significant consequences.

Personalisation algorithms are becoming more and more reliable nowadays, yet large volume of research and studies are required to make them right. It is not surprising that a convincingly-looking *personalisation* algorithm with reasonable theoretical background may simply fail to produce desired outcome or even make the situation worse. However, even in case of most reliable personalisation algorithms, which tested and improved over many studies, the result of personalisation may be wrong due to errors on user modelling side, which result in incomplete or distorted user profile. If a system presents a user with incomplete or inappropriate information, then that system has failed in its primary objective – which is to communicate that information. If a user realises that they are being given unreliable information then that can become very disempowering, and can damage their trust in the system. This is already an issue of some public concern, and it has received coverage in the press.

Jeff Bezos, CEO of Amazon.com, once demonstrated the Amazon recommender system to an audience of 500 people, and it suggested that the movie he would most like would be “Slave Girls from Beyond Infinity” - the system had been skewed by his purchase of the cult 1960s movie “Barbarella” the previous week [11]. Shortly after this, The Wall Street Journal published an article on the perils of user modelling gone awry, entitled “If TiVo Thinks You Are Gay, Here's How to Set It Straight”:

> *Mr. Iwanyk, 32 years old, first suspected that his TiVo thought he was gay, since it inexplicably kept recording programs with gay themes. A film studio executive in Los Angeles and the self-described "straightest guy on earth," he tried to tame TiVo's gay fixation by recording war movies and other "guy stuff."*
> *"The problem was, I overcompensated," he says. "It started giving me documentaries on Joseph Goebbels and Adolf Eichmann. It stopped thinking I was gay and decided I was a crazy guy reminiscing about the Third Reich."*
> *[27].*

2.3 The Human Implications of Personalisation

Most computer interface designers view user empowerment to be a vital aspect of the Human Factors of software design. It is important that users feel to be in control of their own experience. Whether or not this is an issue with personalisation, depends upon how it is implemented. However, this can be an issue with many adaptation systems that aim to be transparent to the end-user. Even some recommender systems are not immune to this if the recommendations are core to the navigation of the information space. When Hypertext pioneer Ted Nelson was on a panel about “the next big thing” in Hypertext, his reaction to a presentation on adaptive hypertext [10] was to shout “*How **dare** your software tell me what I should be reading!*”. There are circumstances under which he has a very good point – users have the right to make their own decisions, and need to feel in control of their experience.

One of the aspirations of many personalisation systems is to make appropriate information more easily accessible for the user, given their current context and goals. However, although this seems superficially very reasonable, it presupposes that making information more easily accessible is always a good thing. While in some areas of application, such as e-commerce, this is undoubtedly true, there are some important applications, such as education, where this is not necessarily the case. In an educational system, the ultimate goal is always to help users learn and learning is about far more than the access, reproduction and retention of information. It is about the internalization and reflection that leads to genuine understanding, and in order for effective deep learning to take place, learners should be actively involved in the design of their own learning experiences [18]. If a user is to develop real understanding of the subject matter, then sound pedagogy is critical and the user needs far more than easiest possible access to the subject matter. In a very real sense, learners need to work at learning if they are to retain information and develop deep understanding. The likelihood of serendipity is one of the great benefits of a rich information universe, and this encourages learners to "think outside of the box". Personalisation, without careful thought about the pedagogy underpinning the instructional design, can make information too easily accessible and this could undermine the learning process. Indeed, the entire intent of personalisation is to render information into constructs that are already understood and preferred by the recipient. This removes many of the challenges involved in understanding the material and can reduce opportunities for cognitive development.

We live in a complex world, and the acquiring the ability to synthesise knowledge from disparate sources is a vital skill. Because personalisation effectively attempts to do this for the user, there is a real risk that the learning process might, to some extent, become "de-skilled" – with the system synthesising knowledge rather than the learner having to do it themselves. It also creates an unrealistic expectation of how information will be available to them once outside the educational environment.

There are other aspects of personalising that need rethinking - what becomes of serendipitous exposure to alternative beliefs, lifestyles and culture? If users filter out information that does not meet their immediate needs or wishes, they are exposed to fewer alternative belief patterns. Not only is restricting one's information diet in this way promoting an insular way of thinking, it reduces understanding between different ways of thought and might even be argued to be divisive. It is critical to apply personalisation without losing serendipity and communication between beliefs.

2.4 Inconsistent Presentation and Outputs

Many personalisation systems, especially those that utilise dynamic data, provide inconsistent results. It is often difficult, if not impossible, to see exactly the same information as another user. This is well illustrated by all of the web sites that deal with volatile information such as currency. For example EBay personalise items by showing the actual price in the original currency, alongside an italicised converted price, and many other information providers (such as weather forecasting services and search engines) filter their content according to the inferred geographical location of the user. Although this can be helpful on occasion, it does mean that the information provided is inherently inconsistent, and this could potentially give rise to inequality and inequities of opportunity. Although this might be only a minor inconvenience (if even that) with currency conversions or weather forecasts, the potential equity problems are far more serious in areas such as education.

A good example here is the research on matching learning content to student learning styles. A number of style-adaptive hypermedia system were created with an assumption that students with specific learning styles may benefit most from specific kind of content, for example, visual learners will need more content presented as pictures. Yet, almost no success reports based on post-production user studies have been published yet. In contrast, other research indicates that students may learn better when they start with least beneficial form of content [15].

Is personalisation actually being misused in the educational context? Yates [26] hints that the classifications of learning styles are being misapplied since they were intended "to help educators recognize the broad range of human achievements, not [attempt] to restrict student instructional practice opportunities to specific domain tasks". Also he notes that it is not necessarily helpful to simplistically categorise students in this way, in fact not only is it difficult to match individual students to a learning style but that it is just as difficult to match an instructional method to a learning style. Mismatch is inevitable.

The answer is not to enforce and restrict access according to the user model but rather to make it a recommended course of action that the student can override. But even then, the "recommendation" may be more harmful that helpful if the style, individual and instruction are mismatched.

2.5 Without Personalisation

So what happens if we don't have personalisation in our computer systems? Does it really matter? Certainly in some cases it seems not, and indeed we seem to get by well enough without personalisation. Even Web and hypertext usability expert Nielsen is quoted as saying [24] that "*There's always been a lot of discussion about personalisation and the web but it has never really taken off, probably because it's not that useful. The only time online retailer Amazon has recommended a book that I really, really want is when it's a book I've already bought*". In an earlier article [20] he went so far as to say that "*Web personalization is much over-rated and mainly used as a poor excuse for not designing a navigable website*". This is not an encouraging analysis from one of the world's leading usability experts.

In some areas, such as AEH (Adaptive Educational Hypermedia), where personalisation has been widely touted as an important technology of the future, it has yet to have much impact on mainstream implementations. The reasons for this are beyond the scope of the current discussion, but this does serve to illustrate the point that whatever its possible benefits, personalisation is not absolutely needed in order to build effective educational systems. Since there are serious concerns about the wisdom (and indeed safety) of personalisation, there is a case for avoiding it entirely.

When we acquire information from any source – online or otherwise – we all get by. The information may not be in the perfect form for us, but we develop coping strategies to allow us to make effective use of it. Indeed, to do so is one of the most important skills that people need to learn to be able to function effectively in an information-rich society. Although there are a lot of anecdotal accounts, there have not been many scientific studies conducted on the effect that personalised information systems have on their users. One of the few that has been done looked at the effect that e-learning systems, personalised according to the users' learning style preferences, had upon their achievements. This work found that both for University undergraduates [3] and 8-10 year old children [4], the personalised systems had no significant effect upon learning (as measured in a number of ways). While there are many ways of interpreting these results, a likely explanation is that even by the age of 8, people are already well-practised at extracting information from a wide range of sources, including ones that are sub-optimal for the individual. Therefore, although they might prefer to have information presented to them in one particular manner, it ultimately makes little difference to how effectively they learn. If this is really the case, then it is quite likely that, at least for education, personalisation could well be doomed to have little effect upon how people learn. However if personalisation is genuinely effective, then it is possible that the learning process could actually be damaged if presenting people with information in their preferred styles prevented them from getting practice at dealing with information in other forms.

Where personalisation has been most effective (such as in recommender systems) it has been quite small-scale and is generally little extra functionality added to an existing system. This is probably a useful thing, but the large-scale incorporation of personalisation into educational systems that make wholesale modifications to content or structure is of unproven efficacy, and has serious cognitive, ethical, and even legal ramifications and as such should currently be treated with extreme caution.

3 Antithesis - Personalisation Considered Essential

The antithesis is that personalisation is essential if e-learning is to fulfill its potential in mainstream education. It has major pedagogic benefits, it provides a cost-effective means of facilitating the uptake of appropriate information from the Internet, and it has a humanising effect upon educational experiences mediated by technology.

3.1 Pedagogy

Personalisation is very well established in the world of e-commerce. Recommender systems, usually using some form of collaborative or hybrid filtering, have been widely used for well over a decade and many commercial web sites now provide product recommendation and other forms of personalisation. Major e-commerce players such as Amazon.com, Netflix, Last.FM pay a lot of attention to personalisation because it produces a reliable result measured in dollars. The stakes are high. Netflix, for example, is offering a million dollar prize to a team, which will be able to deliver a 10% improvement in the accuracy of personalisation. Yet, the domain where personalisation is most vital is not e-commerce, but education. It is also in education that personalisation can provide its major impact, although it may be hard to measure it in dollars.

The key rationale for personalisation is that education is a very personal experience. We all have different goals, expectations and backgrounds, and we learn in many diverse ways. In conventional teaching (i.e. pre-computer), this was largely addressed by small group teaching. A teacher with a small group of students, or an individual, will generally tailor the material to the current needs of those students. This is often a dynamic process, in which a teacher will explain a concept and then encourage the learner to reformulate it and explain it back. This will expose the depth of understanding (or indeed misunderstanding) of that concept, and the teacher can then personalise subsequent explanations accordingly [17]. Large group teaching offers much less scope for personalisation, but this was not generally a problem, because large-group teaching scenarios were generally supported by various forms of small-group teaching. However, without personalisation, e-learning generally follows the pedagogical model of lectures far more closely than it does that of tutorials. If there is no personalisation, then the learning experience can only be of a "one-size-fits-all" nature that will never be able to take into account the diversity of individual learners, or even their changing levels of understanding.

It is not surprising that the need for personalisation was recognized in early days of computer-based education. Moreover, the earliest dynamic user models were created in 1970s for so-called intelligent computer-assisted instruction systems (ICAI). Nowadays, e-learning has emerged as one of the leading application area for personalisation [5], yet it is not as widely accepted or implemented in the real-world e-learning as it is in e-commerce.

3.2 Efficiency of Information Presentation and Uptake

One of the major problems facing education in the modern world is the sheer volume of information that learners are faced with, and this issue is compounded by the fact that information on the Internet is of wildly variable quality. Finding information has never been easier. Finding appropriate information for the task at hand is often quite hard. Finding appropriate information and reifying it into knowledge is a learned skill, and if e-learning is to provide a significant component of education, then it is vital that this skill is actively fostered. This is the area where e-learning personalisation can provide a major impact. By modeling the current state of user knowledge, personalisation techniques such as course sequencing or adaptive navigation support [6] are able to guide students to the right information item or educational activity in the right point of their learning. Multiple studies demonstrated that both sequencing and navigation support can improve learning outcomes [7] and decreased time required for mastery learning.

Further impact can be achieved by adaptive presentation of content – once a proper information item or educational activity is selected, personalisation can customise its presentation to the user. Existing user studies indicate that it can increase both the speed and the quality of learning [2]. Therefore, personalisation provides a cost-effective means of filtering information that is presented to users.

3.3 The Humanising Effect

Effectively personalised systems are likely to be perceived by learners as providing a more "humanised" experience. The users should feel that they do actually matter and the "computer as teacher" is providing them with a personal touch in the whole experience. E-commerce companies that utilise personalised systems, routinely use this humanising effect very successfully as a selling tool. A major motivator for the use of educational technology is that modern class sizes are getting bigger and more students opt for external (or distance) education and therefore anything that can combat the dehumanization of this mass produced education is likely to be valuable.

Many user studies demonstrate a positive student attitude to personalised e-learning systems. Through questionnaires, the students typically rate their experience with personalised systems higher than with non-personalised ones. Does the student positive attitude matter? In modern e-learning it certainly does. As both distance and traditional education become more student-driven, the student willingness to work with pedagogically-efficient content is vital. A number of educational innovations tested in research labs fell short of expectation in a real classroom due to the lack of motivation to use it from the student side. It seems this motivation can be significantly increased by providing personalisation. Long-term user studies of ELM-ART, one of the first adaptive e-learning systems, demonstrated that students working with the adaptive version of the system are willing to spend twice as much time learning with the system with no additional incentives [25]. More recent semester-long studies both this motivational effect and its magnitude [9]. Students working with an adaptive version of e-learning portal were willing to put in two to three times more work with educational content than those using a non-adaptive system.

3.4 Without Personalisation

The relevance of the majority of educational experiences is dependent upon the use to which those experiences are to be put, which is in turn dependent upon the goals and backgrounds of the individual. Without personalisation we miss opportunities to smooth the information flow, and the development of understanding within these varied contexts. Ultimately, without personalisation, e-learning is only ever going to be a generic “mass produced” experience and will tend towards a model of teaching that makes the computer a virtual lecturer, rather than a virtual personal tutor.

Tapscott [23] even goes so far as to say that the entire pedagogical model of learning must change with the new technologies, and that "Net Generation" teaching requires "*shifting from a broadcast style and adopting an interactive one*" and that teachers "*need to tailor the style of education to their students' individual learning styles. Because of technology this is now possible. But this is not fundamentally about technology per se. Rather it represents a change in the relationship between students and teachers in the learning process*". We have the necessary personalisation technology to do this, and we need to use it in order to educate and engage the new generation of learners. Without it, the university as an educational entity becomes increasingly redundant and archaic.

4 Synthesis - No Silver Bullet But Hope for the Future

The main take-home message from this discussion is that the community needs to better understand where personalisation is useful, where it is harmful and when it is justified by the benefits. There is not at present a strong case that personalisation works in e-learning, in fact some evidence that it does not, but there is some hope for it, given the evident success of personalisation in the recommender systems of e-commerce. Personalisation can improve information access in so many ways but we need to be wise in its application so that we do not encounter the issues in section 2.

This is now starting to happen, with for example Kobsa [16] mapping out requirements for privacy in personalisation. Kay [14] looks at how to empower the student by giving them scrutability and control over the system-held data about them. We are also starting to see guidelines on designing for personalisation in website, presumably driven by corporate need [21]. We need the same experience-driven guidelines and principles in personalisable e-learning systems so that we do not inadvertently disadvantage our students in subtle ways.

The lessons do not only extend more widely that in e-learning. For example, attempts to create adaptive menus which re-order menu items according to the system's perception of relevance to the user [13] should be considered by those who aim to re-order search engine results sets according to relevance, e.g. [22].

What we need now is more scientific evaluations in different contexts, generating the hard evidence we need to determine where personalisation works and where it does not work. We know that personalisation can be useful but need to discover where, when and how. To paraphrase Bilbo Baggins, that discrimination is "what this [community] needs to decide, and all that it needs to decide". Personalisation is valuable as long as we think through the implications and know when it is beneficial. As with any technology we should not mindlessly embrace it but carefully analyse it for where it can be useful, so that the full promise in personalisation can be realised.

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On Social e-Learning

Won Kim and Ok-Ran Jeong

Sungkyunkwan University
Suwon, S. Korea
wonkim@skku.edu, orjeong@ece.skku.ac

Abstract. Social Web sites include social networking sites and social media sites. They make it possible for people to share user-created contents online and to interact and stay connected with their online people networks. The social features of social Web sites, appropriately adapted, can help turn e-learning into social e-learning and make e-learning significantly more effective. In this paper, we develop requirements for social e-learning systems. They include incorporating the many of the social features of social Web sites, accounting for all key stakeholders and learning subjects, and curbing various types of misuses by people. We also examine the capabilities of representative social e-learning Web sites that are available today.

Keywords: social e-learning, social Web sites, social features, user-created contents.

1 Introduction

Social Web sites include social networking sites and social media sites. Social networking sites help people establish online people networks, and communicate and stay connected with them [1][2][3][4][5]. Some of the most popular social networking sites include Facebook, MySpace, Windows Live Space, Habbo, Hi5, Bebo, Meebo, Friendster, Twitter, etc. Facebook and MySpace each has over 250 million members. Social media sites help people share user-created contents (UCCs), that is, post, view, and express opinions on them. Some of the most popular social media sites include YouTube, Flickr, Digg, MetaCafe, Hulu, etc. YouTube is the third most trafficked site among all Web sites (social or otherwise), after Google and Yahoo. Today social networking sites and social media sites have been converging: social networking sites have been adding essential features of social media sites, and vice versa.

[6] provides a comprehensive survey of social Web sites, and examines essential features, along with many types of uses and misuses, of social Web sites. The essential features of social Web sites include personal profiles, establishing connections, joining groups, communication among connections, information search, UCC sharing, and expressing opinions. These features, appropriately adapted, can turn non-social Web sites into social Web sites. In particular, they can turn e-learning systems (sites) into social e-learning systems (sites). In fact, some social e-learning sites are now

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available, with some social features in limited sophistication. The sites are not yet richly endowed with social features, and the number of users and amounts of UCCs are not large, at least by the standards set by today's popular social Web sites. Further, the sites have exposed some problems resulting from various types of misuses by irresponsible people. For example, many users seek answers to take-home exams from their online networks, and post past exams to the sites. Nonetheless, in our view, these sites have hit on a worthy concept and are opening up the field of social e-learning.

In this paper, we develop requirements for social e-learning systems. The requirements include adapting and incorporating essential social features of social Web sites, reflecting the needs of all the stakeholders and subjects of e-learning, and controlling the effects of various types of potential misuses of social e-learning systems. We also review the current state of social e-learning Web sites to show how far they will have to go as fully endowed social e-learning systems.

2 Social Features in Social Web Sites

[6] provides taxonomy of essential features of social Web sites. We list these features in Table 1. In this section, we summarize each essential social feature. Readers interested in more detailed discussions should read [6] or, better yet, join some of the social Web sites (e.g., Facebook, MySpace, LinkedIn, Twitter, YouTube, Flickr, Digg, MetaCafe,…) We will discuss changes needed to these features in Section 3.

Table 1. Essential social features for social Web sites

no.	**social features for social Web sites**
1	personal profiles
2	establishing online connections
3	participating in online groups
4	communicating with online connections
5	sharing UCCs
6	expressing opinions
7	finding information
8	open API for third-party applications
9	connecting with other sites

2.1 Personal Profiles

The personal profile is a personal homepage for a member of a social Web site. It includes a range of personal information about the member. It is used for a member to attract other members as online connections who may share common interest or background. It may be as simple as just the name and physical location of the member (on Twitter). It may be much more elaborate and include four types of information: basic information, personal information, contact information and education & work information (on Facebook). The basic information includes the name, photo, age, birthday, relationship status, gender of interest, and type of relationship desired (friendship or dating). Personal information includes interest, favorite music & TV shows, movies, books, and quotations. Contact information includes mobile phone, landline phone, address, etc. Education and work information includes the names of schools attending/attended (high school, college), and current employer.

2.2 Establishing Online Connections

A key asset to a member of a social Web site is the number and quality of online connections he has. Social Web sites provide various means to help a member to build up his online connections. These include automatic discovery of existing members of a site from the email and messenger address books of a new member, browsing of the members of the existing groups on the site, a friend-recommendation engine that suggests friends of friends, and a keyword-based search engine for the names of people. When a member selects a connection candidate, the site sends "friend request" notices to the candidate. Once the candidate accepts the friend request, the online connection is established and they can view each other's profile, and are placed on the list for future status feeds.

2.3 Participating in Online Groups

Social Web sites host online groups. Members can join any number of groups to browse the members of the groups, browse and post comments to discussion boards, receive notices about the activities of the groups, etc. The groups include several built-in groups (e.g., common schools attended, common employer, common physical location), and those that the members have formed. Members and non-members can usually view all groups. However, only members may post comments and other UCCs. Such sites as Facebook, MySpace, LinkedIn, YouTube, etc. have thousands of groups. The groups come in three types: open to the public, open to the public but by invitation only, and private. Usually, a manager is designated for each group.

2.4 Communicating with Online Connections

Members of social Web sites are given various means to communicate with their online connections. These include email, text messaging, instant messaging, bulletin boards, blogs, comments, and even Internet phone service (e.g., Skype). To try to prevent spamming, before sending email and text messages, the sites often require the member to verify the CAPTCHA (Completely Automated Public Turing Test to tell Computers and Humans Apart) code.

2.5 Sharing UCCs

Members of social Web sites can view and post various types of UCCs, including text comments, bookmarks, blogs, microblogs, photos, music, images, video, etc. Members can often also create private collections of favorite UCCs for future viewing and sharing with other members. Because it is difficult for computer software to automatically identify the UCCs based on contents, the members are encouraged to provide titles and tags for the UCCs when they post UCCs. The keyword-based search engines save such titles and tags and make use of them when searching for UCCs.

2.6 Expressing Opinions

Members of social Web sites have various means to express their opinions about the UCCs on the sites. They may leave comments on the UCCs, vote on them, forward them to other members, save them in blogs or private collections of favorite UCCs, and flag them as spam.

2.7 Finding Information

Social Web sites provide two types of facilities for the users to find the information they need. They are keyword-based search engines and browsing. Both members and non-members can search for the names of people, names of groups, and particular UCCs. The scope of keyword-based search can be narrowed to a particular category supported by the sites: for example, people, jobs, companies, etc., in the case of LinkedIn; channels, and playlists, in the case of YouTube. The users can browse members of selected groups and the UCCs in a selected category. The categories may include subject categories, such as technology, world and business, entertainment, sports, etc. (Digg); they may also include top 10 most popular, in past 24 hours, one week, one month, and one year (Digg, YouTube, etc.) The users can also browse the results of keyword-based searches; and friends, groups and UCCs that are "related" to the ones they may be currently viewing.

2.8 Open API for Third-Party Applications

In 2007, Facebook published an open API (application programming interface) to allow third-party application developers to develop applications that can run on Facebook [7][8]. The Facebook API, or Platform, consists of a Facebook's variant of HTML, named Facebook Markup Language (FBML), and a Facebook variant of SQL, named FQL (Facebook Query Language. This API allowed Facebook members to access many non-Facebook applications, and third-party developers an opportunity to attract Facebook members as users. The members' social data can be shared between Facebook and third-party developed applications.

About a half year after Facebook's launch of the Facebook Platform, Google launched Open Social which includes such social functions as member registration, member profile, review, comment, photo-sharing, etc. [7]. Open Social is based on open standards JavaScript and HTML. Open Social, when embedded in a Web site, makes the Web site a social Web site.

2.9 Connecting with Other Sites

The members of multiple social Web sites have the onerous chores of having to establish friends multiple times, and to log on to different sites to connect up with their friends there. Facebook Connect [9][10] and Google Friend Connect [11][8] make it possible for a member of one social Web site (say, Facebook) to link to another social Web site (say, Yelp), using a single sign-on credential. Using a secure authorization

API, the member of one site (say, Facebook) can connect and interact with new friends on the other site (say, Yelp).

3 Towards Social e-Learning Systems

Social e-learning systems need to support a range of features. Full systems may be thought of as today's learning management systems augmented with social features adapted from social Web sites. Simple systems may be Web sites that include only some of the social features for collaboration.

To build and operate social e-learning systems, three key issues need to be addressed. First is to account for the stakeholders who will use the systems, and the learning subjects the stakeholders will deal with. Second is to incorporate essential social features into the systems. Third is to deal with the problems caused by the inevitable misuses of such systems by irresponsible people. In this section, we discuss each of the three key issues.

3.1 Stakeholders and Learning Subjects

Social e-learning systems may be used by students, parents, teachers, and learning administrators. These four sets of stakeholders will form several types of networks, as summarized in Table 2. These include student networks, parent networks, teacher networks, administrator networks, and networks of some combinations of the four.

Teachers need to be able to post announcements, lecture materials, study guides, homework, exams, and grades. Teachers need to be able to participate in groups and communicate, with other teachers, and possibly also with tutors, and learning administrators. Teachers need to be able to communicate with students for a variety of reasons. They also need to be able to answer questions students may post explicitly.

Students need to be able to view all the materials their teachers post, post homework, completed essays, and completed exams. They need to be able to post questions explicitly, and receive answers. They also need to be able to form and work with study groups. They need to be able to volunteer as tutors.

Table 2. Stakeholders of social e-learning systems

no.	types of networks
1	network of students
2	network of parents
3	network of teachers
4	network of administrators
5	network of students and teachers
6	network of students and administrators
7	network of teachers and parents
8	network of teachers and administrators
9	network of parents, teachers and administrators
10	network of students, teachers and administrators

The parents need to be able to participate in groups and communicate with other parents, and possibly with teachers and learning administrators.

The learning administrators need to be able to participate in groups and communicate with other learning administrators, and possibly with teachers, students, and parents.

We note that there are actually two additional sets of stakeholders, namely tutors, and the e-learning infrastructure administrators. Tutors may be students or teachers or just knowledgeable persons. Although tutors can certainly be included, for simplicity, we do not consider tutors explicitly. E-Learning infrastructure administrators administer all learning/teaching tools, the e-learning Web site, and the IT infrastructure for supporting all the tools and the e-learning Web site. As they are not users of e-learning systems, we also do not consider them explicitly.

The learning subjects that e-learning systems must deal with are determined by the types of students. There are several types of students: students earning course credits for degrees/diplomas from accredited secondary schools, junior colleges, vocational schools, universities, and cyber universities; students seeking certificates from trade schools; and people interested in learning about some subjects for personal or professional growth; etc.

3.2 Social Features in Social e-Learning Systems

The features discussed in Section 2 need to be adapted for social e-learning. The reason is simply that the social features in social e-learning systems are to support learning (teaching, and learning administration), while those in social Web sites are to support socializing. Some of the social features in social Web sites can be used as they are in social e-learning systems. Below, we discuss those social features of social Web sites that require adaptation.

(1) Personal Profiles

The personal profile for social e-learning systems will be very different from those for social Web sites. It should consist of two key sections, in addition to minimal personal information (name, physical location, etc.): learning-relevant information about the stakeholder, information about the learning subjects. The learning-relevant information about the stakeholder would differ depending on the stakeholder. If the stakeholder is a student in a degree-conferring school, it would include such information as the name of the school he is attending, the year and semester he is enrolled in the course. The information about the learning subjects would include the name (title) of each of the courses he has taken or is taking or is planning to take, and the types of "relationship" he has with respect to the course. The relationship would include "seeking study group members," "seeking tutors," and "offering tutoring service." For a student who is interested in learning something about a subject on his own for personal or professional growth, the information can simply include the name of each of the subjects he is interested in. and the types of relationship. If the stakeholder is a parent, teacher, or learning administrator, the personal profile would be different from that of a student. As it is fairly obvious, we leave it to the reader as an exercise.

(2) Establishing Online Connections

This feature requires no change.

(3) Participating in Online Groups

Social e-learning systems and social Web sites need the same underlying facilities to support groups. Users should be able to form and join groups (including study groups) based on learning subjects. The only change needed from social Web sites would be the default groups the sites provide. The default groups in social Web sites are based on such attributes as schools attended, physical location, employers, jobs, etc. These can help people find candidates for online connections. However, the default groups in social e-learning systems would be based on learning-related attributes. One possible attribute for supporting default groups is the e-learning system stakeholders, possibly based on learning subjects and the types of schools (i.e., high school, college, vocational school).

(4) Communicating with Online Connections

Social e-learning systems and social Web sites need the same underlying facilities to support communication among users. It appears, however, that users of social e-learning systems would usually need the messages to be longer than 140 characters, the limit Twitter imposes. The messages may sometimes need to include mathematical formulas (http://apps.facebook.com/mathmatics). Mathematical Formulas allow users to add formulas to messages and posts. Further, social e-learning systems would not be driven by the steady stream of updates to the "what are you doing right now?" question that drives such social Web sites as Facebook and Twitter.

(5) Sharing UCCs

Social e-learning systems and social Web sites need the same underlying facilities to support the sharing of UCCs among users. However, they differ in the mix and purpose of the media types of the UCCs. Social e-learning systems need to support learning-relevant UCCs, such as lecture materials, announcements, essays, term papers, homework, computer programs, exams, study guides, etc. The lecture materials may be in various formats, including text documents (e.g., in WORD, HTML, PDF format), PowerPoint presentations, and slide shows, as well as photos, audios, and videos.

(6) Expressing Opinions

Social e-learning systems and social Web sites need the same underlying facilities to have users vote on and express opinions about UCCs posted and subjects under discussion in groups, etc. Social e-learning systems should add a few additional aspects of the UCCs for people to vote on. These aspects would include any combination of such qualities as "authoritativeness," "clarity," "accuracy," "recency,", "easy to comprehend," etc. for the UCCs as learning contents.

On an e-learning system, it would be useful for people (say, students) to post questions to a question and answer board, and have others (say, other students, tutors, teachers) to answer them. The question and answer board represents a specialized use of a general discussion board found on social Web sites. The number of answers posted may be displayed for each question. Users may rate the answers posted. In order to encourage people to volunteer answering the questions, the e-learning system may reward people who post a large number of answers and receive high ratings for the answers.

(7) Finding Information

Social e-learning systems and social Web sites both need keyword-based search engines, category-based browsing, and browsing of related information. However, these facilities need to be significantly modified to support social e-learning. The keyword-based search would need to be tuned for combinations of the names of schools, identifiers for the learning subjects (course titles, course IDs, titles of textbooks and chapters, etc.), and the names of people (students, teachers, administrators, authors of textbooks and papers, etc.).

The categories need to be based on subject ontologies, rather than the simplistic categorization used in social Web sites, such as LinkedIn, YouTube, Digg, etc. However, because of the large number of learning subjects, and the fact that many learning subjects may belong to more than one higher-level category, the categorization can easily become unwieldy. The problem of ontology-based categorization of subjects remains a difficult research topic.

(8) Open API for Third-party Applications

Social e-learning systems and social Web sites both can benefit from providing an open API for third-party application developers. We believe it would be in the best interest of social e-learning systems to provide an open-standards-based API, rather than a proprietary API. In other words, we advocate the adoption of Google Open Social approach over the Facebook Platform approach. The types of third-party applications for social e-learning systems would mostly be for learning, rather than socializing.

In fact, many potentially worthy third-party applications have been developed on the Facebook Platform (http://www.collegedegree.com/library/college-life/15-facebook-apps-perfect-for-online-education). These include the following:

"rate my professors
(http://apps.facebook.com/myratemyprofessors , http://ratemypropessors.com),
"JSTOR search"
(http://apps.facebook.com/jstorsearch, http://wwww.jstor.org)
"Webinaria screencast recorder"
(http://apps.facebook.com/webinaria, http://www.webinaria.com)
"mathematical formulas"
(http://apps.facebook.com/mathmatics)
"heymath"
(http://apps.facebook.com/heymath, http://www.heymath.com)

These make it clear that social e-learning systems, too, should provide an open API to make it easy to have existing learning-relevant applications ported and new applications to be developed.

Facebook applications also include some that should be integral parts of social e-learning systems. These include Slideshare (http://apps.facebook.com/slideshare, www.SlideShare.net) which allows users to upload and share Powerpoint presentations and WORD documents; Courses (http://apps.facebook.com/courses) which allow users to upload courses, post announcements and assignments, search university reviews (online university reviews, http://wwww.universityreviewsonline.com), find classmates, create discussions and form study groups; etc.

(9) Connecting with Other Sites

This feature requires no change. Social e-learning sites should be connected to the social Web sites that support Facebook Connect and Google Friend Connect, so that members can share profile data, friends data, and learning-relevant updates across sites.

We have discussed essential social features of social Web sites that require adaptation for social e-learning systems. In Table 3, we summarize the changes needed for each essential social feature from social Web sites to social e-learning systems.

3.3 Misuses

When a huge number of people, from all walks of life and all ages, gather in a virtual community, such as social Web sites, with their true identities hidden, a small segment of the community is bound to misbehave. [6] discusses various types of misuse of social Web sites. Many users post copyrighted materials without authorization from the copyright holders, pornographic materials, commercials, false rumors, false information, etc. Some also launch spam and malware, hijack member accounts, etc. Pedophiles seek preys. Most of these types of misuse will occur on social e-learning systems, too, since the intended purpose of the sites is immaterial to those that misbehave online.

Beyond the misuses that plague social Web sites, academic cheating is one additional type of misuse for social e-learning systems. Some students seek answers to take-home exams. Some even seek answers to lab exercises or in-class exams in real-time (via text messages using mobile phones). Some directly submit, or cut and paste, term papers, essays, computer programs, etc., found on social e-learning systems. Many students use past tests as study guide. Although it is difficult to regard it as cheating, it can be unfair to other students, and it may short-circuit learning for the students who only study the exam questions. The use of past tests occurs frequently in traditional courses; when they are posted to social e-learning systems, they can become available much more widely and readily.

In any case, there has to be coordinated efforts between schools/teachers and operators of e-learning systems to prevent cheating and take action when cheaters are caught.

Table 3. Comparison of social features in social Web sites and social e-learning systems

no.	essential social features	social Web sites	social e-learning systems
1	personal profiles	- basic information, - personal information - contact information, -education & work information	- minimal personal information - learning-relevant information about the stakeholder -information about the learning subject
2	establishing online connections	-automatic discovery of e-mail and messenger address books of a new number -browsing of members of the existing on the site - a friend recommendation engine - keyword-based search engine for the name of people	no change
3	participating in online groups	- built-in groups (e.g., common schools attended, common employer, common physical location) - three types: open to the public, open to the public but by invitation only, and private	- based on e-learning system stakeholders - based on learning subject -based on types of schools (high school, college, vocational school)
4	communicating with online connections	- e-mail, text messaging, instant messaging, bulletin boards, blogs, comments, and even Internet phone service	-massage with long characters and mathematical formulas
5	sharing UCCs	- various types of UCCs, including text comments, bookmarks, blogs, microblogs, photos, music, images, videos, etc.	- the learning – relevant UCCs, including lecture materials, announcement, essays, term papers, homework, computer programs, exams, study guides, etc. -various formats including text document, powerpoint presentation, and slide shows, as well as photos, audios, and videos
6	expressing opinions	- leave comments on the UCCs, vote on them, forward to other members - discussion board	-voting on additional aspects (authoritativeness, clarity, accuracy, recency, easy to comprehend, etc.) - question and answer board
7	finding information	- two types of facilities (keyword-based search engines and browsing)	- keyword-based search (combinations of the names of schools, identifiers for the learning subjects)
8	open API for third-party applications	- Facebook API for third-party applications - Google open social	- learning –relevant applications
9	connecting with other sites	- Facebook connect - Google Friend connect	- adopt Google Friend Connect

4 Current Social e-Learning Sites

There are many e-learning sites. However, there are only a small number of social e-learning sites. These include Cramster, Course Hero, and Koofers, and Enotes [12][13]. In this section, we briefly survey the capabilities and facilities of only Course Hero and Cramster. These sites support some of the social features outlined in Section 3, and even those features that are currently supported have room for substantial improvement. The other two sites are even more limited in scope and maturity. Koofers currently limits membership to students and teachers of 25 US state colleges, and allows students to rate instructors so that new students may use the ratings in selecting courses and instructors to take. Enotes is currently designed to serve mainly high school students, and limits its scope to English literature. It supports peer discussion groups and questions from students to paid experts (teachers).

Course Hero

Course Hero started in 2008. It currently serves college students and covers a wide range of subjects. It claims to have amassed 2 million course documents from 3,000 colleges. Course documents include lecture notes, homework, graded essays, old tests, etc.

Course Hero claims to have answers to 200,000 exercises in many of 300 textbooks. However, most of the answers are from students. Course Hero reportedly has 300,000 members. Basic members do not pay, but are required to upload course materials. Basic members can access textbook solutions free of charge if they upload a certain number of materials. The site practically hounds users to upgrade to premier membership! Premier members pay $20 a month.

Course Hero provides a Facebook-style personal profile page that it calls "my dashboard." The member fills in information about the courses (he is taking or took), and the types of interest for the courses. The information about the courses includes the name of the college, department, year and semester, course title, course number, and professor teaching the course. The types of interest for the courses include finding study materials, sharing (uploading) study materials (for free membership), finding textbook solutions, finding a study buddy in the same college or elsewhere, finding a tutor, and becoming a paid tutor. Course Hero attempts to find study buddies in the same college as the member's or elsewhere.

Course Hero provides rather simplistic keyword-based search facilities for study materials and textbooks. The keywords for study materials include subject area (e.g., math, history) and course title (e.g., calculus intro, American history intro). The users may select from A to Z for the names of textbooks.

To become a member of Course Hero, one must be a member of Facebook. Course Hero is connected with Facebook, via Facebook Connect. As such, the Course Hero's member can find Course Hero friends on Facebook, and the activities of the Course Hero's member are published on the member's Facebook bulletin board (which Facebook calls the "wall").

To deal with cheating, Course Hero warns students against cheating and plagiarism, and has honored requests from professors to remove certain materials.

Cramster

Cramster started in 2003. It focuses primarily on math and science subjects. The subjects include biology, chemistry, physics, math, computer science, electrical engineering and mechanical engineering. Cramster is currently designed for high school and college students. The stakeholders it currently supports include parents, teachers, and what it calls subject enthusiasts.

Cramster claims to have 500,000 registered members. People can access Cramster free of charge and read solutions to odd-numbered exercises in textbooks. They have to pay for solutions to even-numbered exercises! Cramster charges $10 a month for subscription.

Currently Cramster offers step-by-step solutions to exercise problems in 225 textbooks. It also offers practice questions in the subject areas it supports. The site includes a question and answer board for students to post questions and receive online tutoring by other students and teachers. The site has a "resources" page where students may view and post study guides. Study guides include lecture notes, video lectures, practice exams, outlines, equation sheets and helpful Web pages. The site also has a "study blog" page.

Cramster provides a personal profile page called "my cramster." The profile includes bookmarks and activity summaries. Bookmarks are for textbooks, chapters of textbooks, learning resources found, posts on the question and answer board, and practice questions. Activities include questions submitted, answers given to questions, learning resources posted, and quizzes taken.

Cramster supports keyword-based search for textbook help postings, practice questions postings, question and answer board postings, resources postings, and study blogs postings.

Cramster has 3,000 "experts" (students, teachers, and others) to answer questions posted. The experts are rated for quality, and earn points for rewards, such as iPods and gift cards.

Cramster states on its site that it will ban users who commit academic cheating, and offers to work with teachers who may catch cheating.

5 Concluding Remarks

Social Web sites have demonstrated the yearning of people around the world to socialize with online networks and to share UCCs. We believe that the essential social features of such sites have many other human endeavors. One of them is e-learning. By adding the essential social features, e-learning can be transformed to social e-learning. By engaging potentially many other people who may share a user's learning-related interests and who may possess expertise or information, the user can learn better.

In this paper, we first summarized the social features found in social Web sites. We then developed requirements for the development of social e-learning systems. Then we surveyed a few representative social e-learning Web sites that are available today. There is a large gap between a potential full-featured social e-learning system and the existing ones. However, we believe that these sites are opening up social e-learning.

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Web-Based Learning – Yes We Can!

Ulrik Schroeder

Lehr- und Forschungsgebiet Informatik 9 (Computerunterstütztes Lernen) and CiL (Center for integrative Teaching and Learning), RWTH Aachen University, 52056 Aachen, Germany
Ulrik.Schroeder@rwth-aachen.de

Abstract. Web-based Learning has become a matter of fact at universities. We are now at the edge of new developments with Web 2.0 applications and social software is radically changing the way of how we communicate and share in social networks. Can we expect an analogous revolution for university education 2.0? I will give some arguments that I rather expect an incremental evolution than a radical change. First, I take a look at current eLearning implementations and organizational frameworks and give an example from RWTH Aachen University. Against the background of cognitive theories the utilization of Web 2.0 applications are promising to strengthen 21st century learning. But methods and tools must be adapted to the context of institutional learning as well as the formal regulations must be adjusted vice versa.

Keywords: Technology enhanced learning, Web-based learning, Web 2.0, eLearning 2.0.

1 Introduction

When I started experimenting with Web-based learning in 1993 eLearning was not popular at universities. That soon changed, when Web technologies were rising fast, taking along with it Web-based learning up to new heights. Soon, there were funding programs in many countries. After the dotcom bubble burst also the hype about eLearning seemed to diminish. The pendulum swung back to the other extreme: suddenly all the investment seemed to be lost, projects ran out, researchers had to leave the universities, taking most of the accumulated knowledge about eLearning with them. The majority of opinions of university teachers were critical, such as “technology had never proven to hold its promise in education”. The truth is to be found somewhere in between those extremes. Today, without much notice, technology enhanced learning is well established at higher education institutes [1, 2, 3, 4]. It has found its specific form as blended or hybrid learning, which blends online and offline teaching and learning support.

In this paper, I want to discuss the meaning of technology enhanced learning[1] for universities. What are the differences to corporate eLearning? Why does it take longer to develop and blossom? What is the current state of eLearning at universities and

[1] Terms such as web-based learning, eLearning, and TEL are rather synonymous and are used interchangeable within this paper.

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what are future trends? In section 3 I roughly describe the implementation of RWTH Aachen University's eLearning strategy. A good eLearning infrastructure is necessary, but not sufficient for successful eLearning. Thus, in section 4 we will have a short look at the learning which is to be supported by Web technology: If we want to support learning, then we have to consider the learning processes which are constraint by our cognitive system. How do we learn? What are the processes of acquiring, transforming, storing and applying knowledge? Which factors influence learning? In section 5 we will come back to eLearning trends which affect teaching in learning in near future. The growing emergence of Web 2.0 tools and social software and the development of mobile technology are very promising in the field of education. ELearning 2.0 [5] shows great promise and seems ideal to implement constructivist learning models. Still there are remaining challenges and not all of the expectations will be met.

2 Implementation Strategies for Blended Learning at Universities

Why did it take longer for eLearning to flourish at higher education institutes in comparison to corporate learning? First of all, there are differences in objectives and application context. One big factor for corporate eLearning is cost efficiency. Employees can learn from their workplaces and save travel expenses and reduce time being absent or even learn from home during spare time. Students at universities are expected to be full-time students and study on campus[2]. Thus, there are no savings to be expected from distance eLearning. Instead, lecturers at universities expect to utilize innovative pedagogy and advance more student-centered approaches in order to motivate and activate students without increasing the workload for teaching too heavily.

University learning takes place embedded in social communities. Traditional lectures have been criticized as ineffective, because students are passive. I am still very much in favor of good lectures. A good lecture mainly introduces students to problems and the way of thinking and problem-solving in a discipline. The lecturer as the expert chooses the topics which are important, the examples and the sequence to be presented and acts as an archetype for the domain. Most important is raising an interest for the topic, and show enthusiasm for the domain and its methods. But this is only the start for learning. More takes place in accompanying exercises and weekly assignments. Students work on problems, repeat mentally what they have been displayed to in lectures, take additional resources like books or eLearning materials such as slides, lecture notes, video captures of lectures, etc. So learning in lectures is a complex blend of opportunities, mentoring, coaching, and social embedding. And at this, technology enhanced learning in the sense of enhancing the existing successful methods is on its best.

Current studies show that technology enhanced blended learning has become a matter of fact at most higher education institutes. Blended learning is understood as a blend of

[2] Except for part-time study models and distance universities.

online and face to face teaching methods ("on campus eLearning" as opposed to "distance eLearning"). It is the predominant form at universities, far more important than online (distance) courses even though it is composed of the same components of technology.

In Germany, the study "Learning within the Web 2.0" [1] shows that 86 % of students utilize relevant eLearning elements in their major topics. 73 % of all students use the Web between one and three hours a day, 23 % even between 4 and 6 hours (not all for study reasons though). The most popular "eLearning services", provided by the universities are portals for organizing studies (enrollment, register for classes and exams, information about courses, evaluations, etc.) followed by rather static (non-interactive) learning objects such as lecture notes, slides and eLectures (video capturing of lectures provided as videos or video-podcasts). Only the third but still widely used technology are interactive tests.

Similar numbers are reported for US universities, were 93 % of university teachers have some experience with blended learning [2, 3, 4]. However its use in 2004 still was rather modest, with only 20 % or less of the taught classes overall, but with expectations of a substantial growth in blended learning in the coming years. Similar developments are true internationally, with slight differences depending on university traditions, e.g. Australia has a bigger part of online courses due to a strong history in distance learning.

Many studies and reports document that most universities embrace blended learning approaches. There are however many different strategies of how to implement blended learning. While the first experiments with new technology and utilizations in courses usually start as grass root activities by early adopters, it needs a top down strategy and central eLearning policy by university administration. There is no panacea of how to implement eLearning at higher education institutions. A variety of successful strategies have been reported [6, 7] which involve mutual dependent aspects of didactics, technology, culture and economics.

RWTH Aachen University's eLearning center CiL focuses on supporting measures which aim at broad effects which lead to a sustainable development of a new blended learning culture [8, 9]. CiL favors a low-threshold approach which is seamlessly integrated in a coherent way with IT-supported administrative workflows such as administration of student lifecycles, examination results, booking of lecture halls, organizing time-tables for classes, registering to courses and examinations etc. Even if high-end eLearning projects could serve as show cases for eLearning possibilities, experience has shown that they are rather discouraging, because the high-polished results can only be achieved with extra funding which is not available in the normal teaching situations. The RWTH learning and teaching portal[3] L²P offers the standard functionality of learning management systems such as Blackboard, WebCT or moodle, but all the organizational workflows are seamlessly integrated with the campus management system and university identity management. It is implemented with portal software and integrates various IT systems via Web-services. Thus, using L²P does not generate additional overhead for lecturers or students and neither data nor workflows are redundantly duplicated.

[3] German acronym: **L**ehr- und **L**ern**p**ortal.

3 Blended Learning at RWTH Aachen University

Lecturers can create virtual course rooms for each of their courses (lectures, seminars, exercises etc.) which are defined in the campus management system by one mouse click. Each student, who has enrolled for such a course via CAMPUS-Office, is readily permitted to access the related course room and is able to retrieve all information and materials for the course; e.g. organisational details, current announcements, learning materials, etc. In the virtual course rooms lecturers and students can easily exchange information; students can control their learning progress, upload homework or allow other students to access their uploaded materials. Furthermore, L²P makes surveys, interactive testing with auto correction and feedback possible. Additionally, it supports several collaborative features such as discussion boards and wiki pages.

The strategy gears towards a grassroots' development. Early adopters easily integrate blended learning components in their way of teaching. Students get used to new eLearning services in these classes and then start to ask for the same in all the other courses. Even though there were no regulations or incentives for faculty, L²P has been widely adopted in many RWTH courses within two years of its introduction. Besides providing Web-based access to announcements, syllabi, and all sorts of learning materials, it facilitates communication and collaboration between faculty and students, and among students. There are two RWTH-specific modules for literature management [10] and workflows for handling weekly assignments with student tutors and managing grading books and interactive tests [11]. The literature module implements an easy definition (browse through various online catalogues) and integration of reading

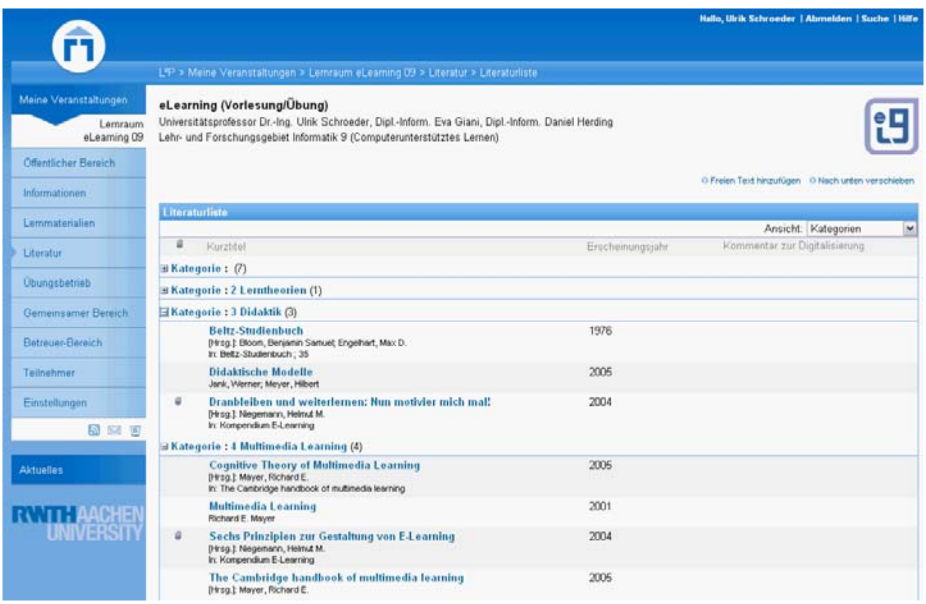

Fig. 1. L²P readings list with attachments of articles, which are made available online by the integrated digitalization process

lists into virtual course rooms. Lecturers can also select parts of books or research articles which are to be provided online within the virtual course room. Library staff then checks whether the selection complies with legal requirements and buy the book if necessary and digitize the chosen chapters if they are only available on paper. The assignment workflow module allows for flexible definition of typical assignment, grading and feedback workflows. Students can work individually or in small self-determined teams on assignment tasks or projects. They can hand in preliminary solutions and receive feedback. Lecturers can define rules of how the overall grading can be composed of the evaluation of single assignment tasks.

While the eLearning infrastructure is necessary, it is not sufficient for innovative and sophisticated eTeaching. The basic blended learning utilization of L²P lays the ground for more sophisticated technology-enhanced learning, which requires more ICT literacy and (media-)didactic competencies. While instructors are experts in their discipline, few have the time or skills to design and develop technically and didactically sophisticated eLearning contents. A big challenge for advancing eLearning is eDidactics qualification as well as technical assistance. CiL offers both, a qualification program as well as support and assistance. The qualification program covers theoretical background to learning and media-didactics, the utilization of relatively simple authoring tools (rapid eLearning production) and best practices of blended learning scenarios.

4 Cognitive Issues of Learning

Learning has existed since thousands of years, while applying technology to learning is a quite new endeavor. There is a lot of scientific knowledge and research about human cognition and learning. So when we design learning technology we must consider how humans learn. Learning is a process of the human cognitive system, which acquires information, stores it for further use and applies it. Regardless of the existing knowledge about human cognition, one challenge still remains: How can this knowledge constructively be applied to instructional design? There are various models of the cognitive system, specifically the working memory [12, 13], explaining aspects of multimedia learning as well as design principles based on these theories [14, 15].

The focus in technology enhanced learning often is laid too much on the acquisition of information only. However, learning mostly comprises of additional elements such as memorizing and changing behavior and attitudes. The success of technology enhanced learning on university level thus depends on how well the complete learning processes conform to the constraints of the cognitive system. One of the constraints is the cognitive load [14, 16]. Instructional design must recognize the constraints in capacity. There are several possibilities to do so: (1) didactically reduce the content to the minimal information needed or (2) specifically tailoring the presentation to the learning situation, e.g. taking prerequisite knowledge into account and utilizing multimedia according to principles of multimedia learning [15].

Even more than details of multimedia design learning at university level must consider emotion and motivation. In order to optimize learning results learners must become active and motivated, they need to be involved, participating and engaged, and they should be interacting with learning materials and produce artifacts themselves.

Technology can help to promote the three C's [17]: Control (by the learner), challenge (of the learning tasks) and commitment (to the learning process). The three C's must be conceptually designed into learning materials by its authors as it has always been the case with the didactic design of lectures and accompanying exercises and labs. The eLearning infrastructure then should support active participation and foster engagement with its communication and collaboration tools. These issues are important factors in constructivist learning models and with the new philosophy of Web 2.0 tools these might even become stronger.

5 The Web 2.0 Way of eLearning

Now let me come back to future trends in eLearning. The influence of Web 2.0 and social software as well as the rapidly evolving mobile technology are the two main driving forces for eLearning [18, 19, 20]. The experience and expectations of learners in the light of their increasing use of mobile and Web 2.0 technologies starts to influence the way they learn, collaborate, and communicate. There is a chance that future students actually will become active participants in the learning process, not mere listeners anymore. Their Web 2.0 experience might lead to students taking more control of their environments. Students will also have a strong sense of communities of interest linked to their Web spaces and a disposition to share and participate. All these changes in behavior carry the chance to implement constructivist learning models where students take more responsibility for their own and the learning outcome of the whole learning community.

Currently traditional learning management systems (LMS) gradually develop into learning portals and integrate Web 2.0 tools such as Wikis, Blogs, Tagging- and Rating-systems and support RSS feeds. Personally, I doubt that merely enhancing learning management systems with Web 2.0 applications will fundamentally change the way of learning at universities. Traditional learning management systems are formally structured environments which represent "eLearning 1.0" and are specifically designed to support formally defined teaching and learning processes by enhancing them with communication and collaboration tools and interactive and multimedia learning materials. These systems more or less unify how students learn and teachers teach. They organize studying in listed courses in order to formally certify achievements. On the contrary, eLearning 2.0 accentuates personalized learning in which students choose their own tools for learning, communicating and networking. [21] Personal learning environments (PLE) "are websites or services where learners are able to produce learning content or reflections and store documentations about their learning processes. […] Furthermore, users should be able to aggregate data from their learning communities, e.g. through RSS feeds or interesting weblogs" [22, p.2]. PLEs are "not a single application, but a collection of interoperating applications – an environment rather than a system." [5]

While there is no technical difference between learning portals which might be defined as "eLearning 1.5" environments and PLEs, there is a bigger gap between their *modi operandi*. Learning portals are provided and administered centrally by university. They optimize formal learning and are easily adopted, because they provide the same tools in all the courses, but therefore have less flexibility than personal learning environments, which can change with upcoming new tools every day. PLEs better support informal learning not restricted by study regulations.

Another difference is given in the preciseness and systematic methodology of sciences. "The notion of collective intelligence is redefining how we think about ambiguity and imprecision. Collective intelligence may give rise to multiple answers, all equally correct, to problems." [19, p. 9] The one opinion published first and cited the most is a good candidate to be taken as the correct or most influential. The way to solve problems is less systematic and more driven by serendipity. It requires a whole new set of information literacy, to find the right information, retrieve and organize it, critically evaluate and attribute it, and finally apply it correctly.

In order to foster networked and open learning in higher education there also has to be a change in the way of assessment and examinations. Unfortunately, currently I see just the opposite happening with the Bologna reform process, which leads to a framework with even stricter rules, more formal regulations, stronger heteronomy and more examinations of individual achievements. [23] Along with it, another discrepancy is the teachers' role in the learning process. The situation in which teachers have to examine and formally grade students makes it hard to be coaches and mentors at the same time.

Last but not least, I am rather skeptical whether simply transferring Web 2.0 models and tools which are successful in social contexts to formal learning will automatically lead to similar processes of networking, sharing and participating. "Imagining technology used for social purposes in a study context presents conceptual difficulties to learners as well as a challenge to their notions of space. They need demonstration, persuasion and room to experiment in this context" [19, p. 6]

Despite these obstacles I still expect a gradual change and development of more open and networked learning which partly has similar characteristics as social web networks. But the models still have to be shaped, organizational rules still have to be adapted and also concepts and tools still have to be designed and evaluated. Some of the challenges that have to be tackled are the new information literacies and digital divide among students but even more so between students and staff. Institutions need to adapt to current student needs and identify new learning models that are engaging and strengthen the three Cs: control, challenge and commitment. "Higher education is facing a growing expectation to make use of and to deliver services, content, and media to mobile devices. This is more than merely an expectation to provide content: this is an opportunity for higher education to reach its constituents in new and compelling ways, in addition to the obvious anytime, anywhere benefits of these ubiquitous devices". [18, p. 6]

6 Concluding Remarks

While Web 2.0 tools promise to support eLearning according to constructivist learning models, it still is an open research question of how to design new tools with social and networking attributes and how to integrate them into formal learning. I am convinced that we still need to find pragmatic ways to adapt higher education didactics to 21st century learning, and qualify faculty and students in the new ways of collaborative teaching and learning.

But looking back the last decade, we already can state that Web-based learning has become reality at higher education institutions. “WBL – Yes, we can!” and chances are very good that it will continue to evolve and incrementally optimize the way of university education. There is still a lot of research to be carried out to incorporate the exciting developments into formal learning. This conference is an excellent chance to advance learning and teaching one step further.

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A Machine Learning Based Framework for Adaptive Mobile Learning

Ahmed Al-Hmouz, Jun Shen, and Jun Yan

School of Information Systems & Technology
Faculty of Informatics
University of Wollongong, Wollongong, NSW 2522 Australia
{aa998,jshen,jyan}@uow.edu.au

Abstract. Advances in wireless technology and handheld devices have created significant interest in mobile learning (m-learning) in recent years. Students nowadays are able to learn anywhere and at any time. Mobile learning environments must also cater for different user preferences and various devices with limited capability, where not all of the information is relevant and critical to each learning environment. To address this issue, this paper presents a framework that depicts the process of adapting learning content to satisfy individual learner characteristics by taking into consideration his/her learning style. We use a machine learning based algorithm for acquiring, representing, storing, reasoning and updating each learner acquired profile.

1 Introduction

Electronic learning (e-learning) continues to grow rapidly but most e-learning technology involves wired infrastructures. It is believed that the emerging wireless and mobile networks will provide new applications in mobile learning [1]. With the rapid evolution of mobile devices such as PDAs, Table PCs and smart phones, pervasive (or ubiquitous) systems are becoming increasingly popular.

Mobile learning (m-learning) is "any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies" [2]. Given the rapid use of mobile technologies for facilitating the learning process anywhere and anytime, learners are able to use idle time, for example, when waiting for public transport, in between lectures, and traveling to and from university. This time can therefore be used more efficiently in terms of learning [3].

The awareness of learning context is important. A learning system should adapt the learning process in response to context change. The main goal for context-aware mobile learning application is to sense the mobile learner's situation (environment) and respond to it [4]. Shilit [5] divided context into three categories: computing context, learner context, and physical context. Chen and Kotz [6] extended this list by adding a time context. The study in [7] identified four categories: identity, location, status, and time. Context has four dimensions in [8]: situation, network, device, and expertise.

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Most current learning contents were designed for use with desktop computers and high-speed network connections. They usually contain rich media data such as image, audio, and video. Learning contents may not be suitable for presentation on devices with limited capability and limited network bandwidth. Moreover, the widespread problem in e-learning environments is that they cannot offer personalization for the student and that they can only present identical contents to all the learners. Mobile based education is already reaching a large number of learners and it offers a valuable advantage over traditional teaching with the possibility to adapt to individual learners, which is hard to achieve in the common teaching process.

This paper presents an m-learning framework. The main objective of this framework is to provide personalization and tackle adaptation using machine learning technique according to obtained user profiles. These user profiles contain users' preferences, knowledge, cognitive, goals, plans, place and possibly other relevant aspects that are used to provide personalized adaptations. Section 2 of this paper discusses related works. Section 3 presents the structure of the proposed framework. Finally, in section 4 we conclude with some comments about future developments related to this work.

2 Related Work

It is possible for learning activity to occur everywhere: educational institutes, within homes, on buses and trains and in parks and restaurants. Unpredicted weather conditions may affect the learner's ability to accomplish a learning task [9].

Mobile learning (m-learning) is still in its infancy and most of the research projects are focusing on the connectivity problem of using wireless networks or the problem of accessing course content using mobile devices [10]. Martin [11] designed a system for recommending activities for learners; this process is dependent on the learner's personal attributes, actions and the current context (location, time, available devices). The system can be used individually or collaboratively. Ogata and Yano [12] designed a context-aware language learning support system for learning Japanese polite expressions.

The MOBIlearn project is an interactive model in which data is collected from sensors, and translated to appropriate services. An adaptive learner interface system has also been developed within this project [13]. In [14], mobile scaffolding-aid-based bird-watching learning system, an outdoor learning system is proposed, meaning that a learner with higher learning efficiency will gain less support from the system. In [15], ketamo have implemented an m-learning environment (xTask) that adapts to different user devices (PC, PDA and WAP devices). xTask also implements a library for managing learning objects in different formats.

Few of the m-learning researchers have tackled the problems of adaptation of learning tasks and personalization of course content based on students' models, learning styles and strategies [16]. These issues have been explored within the traditional web-based systems in numerous well-known projects. ELM-ART [17] is an intelligent learning website environment that supports example based programming, intelligent analysis of problem solutions, and advanced testing and debugging facilities. InterBook [18] is a tool for authoring and delivering adaptive electronic textbooks.

Museum tour guide is another research [19] used mobile devices personal museum expert which is mainly concerned with user location. The ENLACE project [20], referred to as SEO/Birdlife, is a research project implemented in conjunction with teachers in a secondary school.

3 Machine Learning Based User Profile Framework

3.1 Foundation

User adaptive systems aim to adapt learning content, location and presentation to each individual user's characteristics or behavior in order to improve the interaction between users and the system (see Fig. 1). The process is based on storing and exploiting information about the user. However, users differ in traits such as skills, aptitudes and preferences for processing information, constructing meaning from information, and applying it to real-world situations.

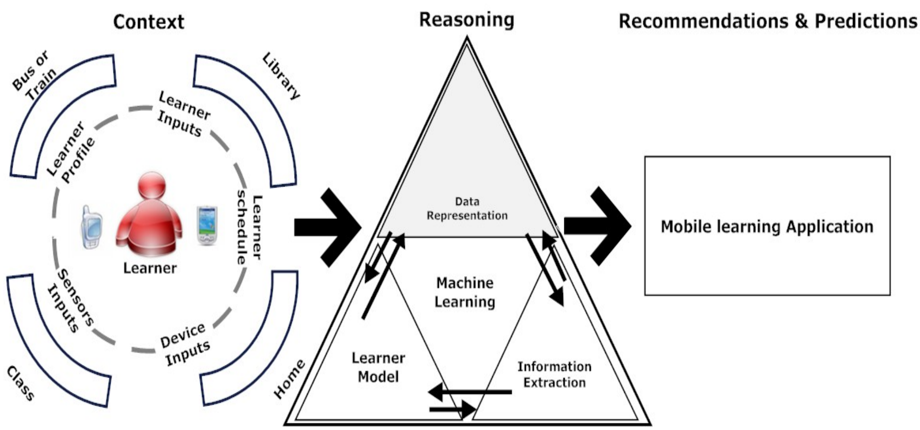

Fig. 1. Basic elements of a user adaptive system

In this respect, modeling the users' behavior is a fundamental mechanism for providing personalization [21]. Depending on the application, user profiles are generated to store information about user preferences, interests, goals, usage data and interactive behavior. User preference is an important concept to predict user behaviors and make appropriate adaptation actions. Preferences can be explicitly supplied by the user [22]. In user-adaptive systems, the user model can be used for various tasks depending on the application [23], for example, to predict user needs on the basis of past user behavior, and to recommend interesting elements to a user based on preferences or previous user behavior.

A Personalization Engine as shown in Fig.1 is usually employed to infer adaptation actions on the basis of identified user characteristics, for retrieving or filtering appropriate content and adapting the content presentation, and to match the navigation support and the interface attributes to the user needs. The framework presented in this paper is principally designed to achieve content adaptation and personalization based on individual users, taking into consideration specific learning styles and subject matter learning motivation [24].

The concept of being context-aware is composed of two elements: personalization related to the learner, and automatic customization related to the adaptation process. Customization for the learner means that the system knows about the learner and changes its appearance or behavior according to learner needs. Automatic customization or adaptation means that the system creates a model for the learner in an automatic (machine learning) way to suits the learner's situation and needs.

It is believed that most people prefer some particular method of interacting with information. These methods of interaction are referred to as learning styles. A learning style is the method of learning particular to an individual that is presumed to allow that individual to learn best [24]. The model foundation is based on storing and exploiting information about the learners. However, learners differ in skills, aptitudes and preferences for processing information and applying this information to real world situations. In that regard, modeling the learner is a fundamental mechanism for providing personalization [25].

It is commonly noted that interactive systems are becoming more complex. Therefore intelligent, friendly learner interfaces and adaptive systems are needed to improve learner interaction with these systems. Furthermore, the exponential growth of the internet and mobile users makes it difficult for learners to cope with the huge amount of available information. The challenge that information providers and system engineers face is the creation of adaptive applications. A learner adaptive system uses the knowledge given by learner models to implement the following tasks [26]:

- Recommendation: the capability of suggesting interesting scenarios to a user based on some information; and
- Classification: building a learner model that classifies related data into one of several predefined classes.

3.2 Layer Model Components

Within the model, we first consider the application that supplies the events that have occurred in a specific location. In case of mobile learning adaptation, several dimensions of adaptation need to be considered such as [21]: the content dimension, the learner model dimension, the device dimension, the connectivity dimension and the coordination dimension. Within these dimensions, there exist sub dimensions.

In order to provide personalization for individual users, the system must first be able to identify the user in order to collect the information required to perform the personalization (Log-in). This will give better accuracy and consistency. User data is gathered to construct the learner profile. The data collected includes: data regarding the interaction between the user and system, personal information; data regarding the environment of the user when interacting with system; and direct feedback given by the user (see Fig. 2).

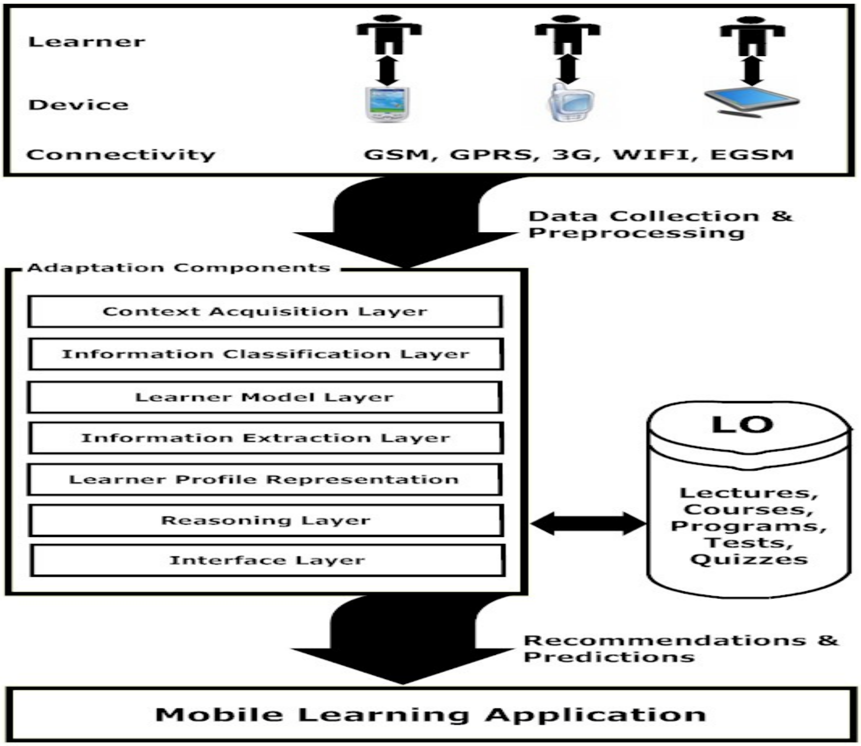

Fig. 2. Adaptation Components

3.2.1 Context Acquisition Layer

The context acquisition layer is used to gather the information required for adaptation. It relies on both explicit and implicit information collection. Explicit information relies on information provided by the user, usually through the use of forms with text boxes and check boxes. It often contains demographic information such as birth date, interests, marital status, job and personal characteristics.

Implicit information is gathered by monitoring the user's interactions with a system and making assumptions as to their motivations and needs. Typical methods for gathering implicit information include determining user position using GPS, and sensing noise or time using a built-in microphone or clock.

Explicit information forms will be filled out just once when the learner uses a system for the first time. Any such form should not require significant extra thinking, typing or memory retrieval. Requests for such information cost users' time, require willingness to participate and require that the system assumes that all the information provided by the user is correct and valid. As well as trusting that users attempt to supply correct information, it is possible that different learners may interpret the questions differently. To avoid this kind of problem the questions asked should be straight forward for users to process. A learner will not notice the importance of supplying this information unless he uses the adaptation system frequently and is aware of the difference in time saving and accuracy of results.

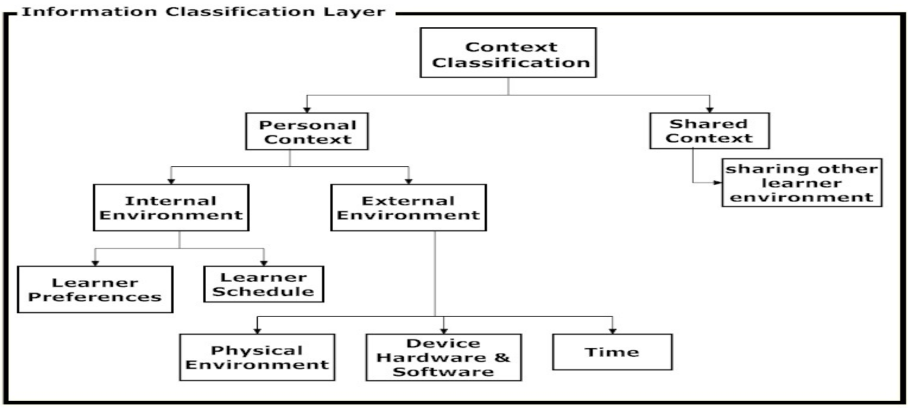

Fig. 3. Information classification layer structure

3.2.2 Information Classification Layer

This layer deals with all data obtained from the previous stage by categorizing the data into several class types as it shown in Fig.3. It consists of two categories: Personal context - all relevant attributes to the learner through out his/her use of the system; and Shared Context - attributes relevant to all learners when using the system.

3.2.3 Learner Model Layer

Learner modeling aims to make information systems learner-friendly by adapting the behavior of the system to the needs of the individual as shown in Fig 4. A learner model should capture the behavior (patterns, goals, interesting topics, etc.) of a learner when interacting with the system.

A learner model is defined as a set of information structures designed to represent one or more of the following elements [22]: Goals, plans and preferences; Representation of relevant common characteristics of learners stereotypes; The classification of a learner stereotypes; Learner behavior; The assumptions about the learner based on the interaction history; and/or The interaction histories of many learners into groups.

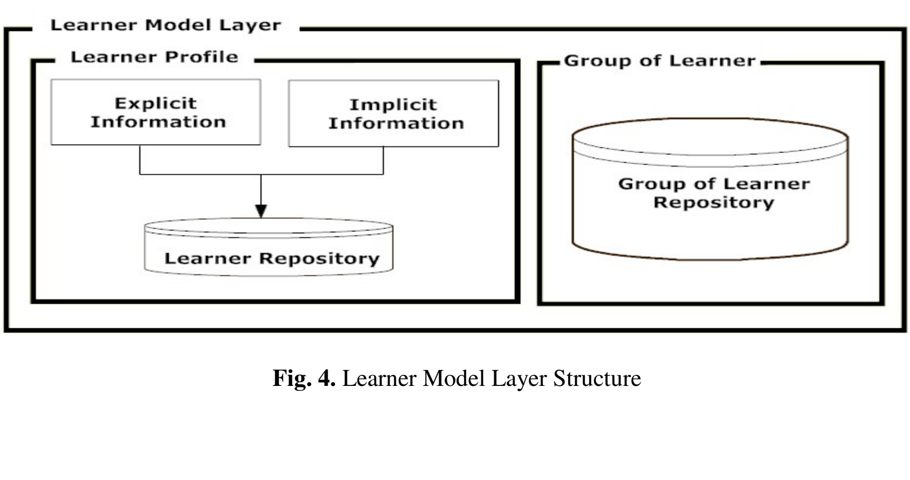

Fig. 4. Learner Model Layer Structure

3.2.4 Information Extraction Layer

The process of adaptation is based on storing and exploiting information about the user. However, users differ in traits such as skills, aptitudes and preferences. In a mobile learning environment, differences in user preferences, types and amounts of content are relevant and critical to the learning process. This layer will assess, analyse, verify and filter the data based on the current user situation.

3.2.5 Learner Profile Representation

In order to achieve personalized services, we must be able to specify user interests. This can be done using a machine learning algorithm, which takes a learner's information for input, then compares and analyses the learner's need, interest and environment. Such profiles can be further enriched with more specific information such as location and time. However, in this context, the focus is on user interests and characteristics. Enriched learner profiles enable the system to select between a number of topics and interests to match with the best learning style for that user.

Creating learner profiles allows for much more accurate results, given a sufficiently expressive keyword. Profiles are derived from a common keywords set. A learner can indicate his interest in a specific domain or even single concept by specifying a value in a predefined range. Precise information allows the system to more accurately support user decision-making.

3.2.6 Reasoning Layer (Machine Learning Layer)

Machine learning techniques have been applied to learner modeling problems for obtaining models of individual learners and group them into categories. This process is very important to have accurate and useful system that can modify its behavior over time. Machine learning techniques are applied to the data obtained in the earlier stages, in order to capture user behavior patterns.

The output of this layer is a set of structural descriptions of what has been learned about user behavior and user interests. Any machine learning techniques based on adaptation should consider the following conditions to provide a wide range of possibilities on m-learning [12]: the amount of effort required to provide the system with necessary background knowledge, the amount of time (computational time) required, the amount of input data required to be able to make useful decisions, and the appropriate handling of noise and uncertainty, and validity. The details of machine learning based adaptation are beyond the scope of this paper and will be addressed in future research.

3.2.7 Interface Layer

The interface layer is formed by the events that are processed by the adaptation system as well as the questions about the learner that it can answer. Furthermore, the interface forms a description of the way the application interacts with the adaptation system. The learner model contains the information about the learner that has been collected so far. One of the main issues related to the interface layer is whether the adaptation system frequently changes the learner interface each time the learner uses the system, or gives the learner the freedom to choose when they first use the system by determining their preferred way of representing the information. These changes include the arrangement of icons and items on the learner's device screen.

In our system we will make a default interface layout with only limited changes to the interface, for example font colour and size. By using a default interface layout with limited changes to the device screen, problems arising from frequent changing interfaces will be minimised. Such problems include: 1) Learners could be prevented from engaging in an automatic learning process with respect to some aspects of the interface and not focusing on the learning procedures; 2) Learners spend more time looking for particular interface elements because every time they use the system the interface will change; 3) Frequent changes in the interface may prevent learners from acquiring skill and speed in using the interface; 4) Unexpected changes may be generally confusing and distracting for the learner; 5) Learners may not be aware or experienced enough to change the interface; and 6) Learners may not want to spend time adapting to the interface. As a result, a suitable default interface layout chosen by the system may be able to choose the appropriate adaptations more accurately than a learner could.

3.3 Learning Objects Repository

A learning objects repository is any written digital material sources. Separating the educational content into small segments allows ease of use of the content. Digital resources are usually described with additional metadata attached to them and later arranged into more meaningful content such as lectures, courses, programs, tests, videos, images and quizzes. Metadata repositories help in categorizing and searching for learning objects.

3.4 Mobile Learning Application

It is important to specify how much control or involvement the learner will have over the adaptation system, from the outset of system development. To make an informed decision, we need to consider the implications of giving the learner full (or no) control over the system. Possible options for determining the users' level of control include: may involve the system submitting all recommended adaptations to the learner, who is required to give their approval before implementation; implementation of automated adaptations with learner ability to undo the adaptations if they do not like them; or even allowing learners to disable the entire adaptations system. Learners expect benefits from using the adaptation system such as saving of time and efforts.

Incorrect action by the system may have serious consequences which will discourage the learner from using the system any more. After consideration of the implications of level of user control, in our framework the system will have full control over the adaptations process with only one option for the learner to disable the entire process. This decision is made for two reasons: to give the learner full control over the system assumes that the learner has a certain level of knowledge about the system (which not everyone has); and to decrease the computational time.

4 Conclusion and Future Work

This paper has presented a new framework that depicts the process of adapting learning content to satisfy individual learner characteristics by taking into consideration his/her learning style. We have described the system architecture of our context adaptation based user profile framework and learning style adaptation which is fundamentally grounded on a number of logical layers: context acquisition, information classification, learner model, information extraction, learner profile representation, reasoning and interface. It is a generic framework for selecting the appropriate learning style for learners based on their learner preferences and contextual features. The implementation of the system is currently in progress and the effectiveness of the system will be evaluated both quantitatively and qualitatively, using a series of simulations and a small number of human users to work with our system. We will also extend our tool for incorporating other types of learning objects and/or materials. The ultimate goal of the framework is to provide a logical structure for the process of adapting learning content to satisfy individual learner characteristics by taking into consideration his/her learning style.

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PASS: Peer-ASSessment Approach for Modern Learning Settings

Mohammad AL-Smadi, Christian Guetl, and Frank Kappe

Institute for Information Systems and Computer Media (IICM)
Faculty of Computer Science
Graz University of Technology
Brückenkopfgasse 1, 8020 Graz, Austria
{msmadi,cguetl,Frank.Kappe}@iicm.edu

Abstract. Students nowadays play major roles in the new culture of assessment where new forms of assessment have been adapted. Several labels have been used for assessment such as *collaborative assessment, self- and peer-assessment.* In this paper, we will present a computer-assisted peer assessment system that can be used to improve the learning process. An overall architecture for this system will be presented and an experiment has been conducted. First findings will be discussed and future work will be mentioned.

Keywords: Peer-assessment, Self-assessment, Online testing, E-learning, Computer-assisted peer assessment.

1 Introduction

In this paper, we addressed an enhanced approach for online peer-assessment where new features of candidate answer marking have been used. Students are capable to select specific parts from the candidate answer and mark them as *correct, wrong, or irrelevant.* Special keystrokes are used to handle these operations where changing the selected part to underlined means that it is write, where to bold is wrong and italic is irrelevant. A Peer-ASSessment system (PASS) was developed for this purpose. PASS was developed using PHP programming language [1] and MySQL database [2]. The system is built on top of Apache Tomcat Servlet (TOMCAT) [3] and applies the MVC (Model-View-Control) approach [4]. PASS consists of three main modules: *User Management Module:* this module handles the authority levels of the systems' users. According to the diversity of the systems' users we have identified three main roles, Administrators' role, teachers' role and student's role. *Test Management Module:* represents the core module in this application. This module is responsible for tests authoring, assessment activities, items preparation, reference answers, marking and final grading. *Results Analysis & Feedback provision Module:* this module computes the final grads of the different assessment activities.

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2 Experiment Setup

The experiment was conducted as an e-learning activity for the course of "Information Search & Retrieval (ISR)" at Graz University of Technology in the winter term 2008/2009. A group of 27 students enrolled at the course of ISR. The students were separated into two groups 12 for the first group and 15 for the second. All of them participated in the experiment. 14 (51.9%) of the students were taking part in the course as a bachelor program, where 13 (48.1%) were master students. 3 (11.2%) were females and 24 (88.8%) were males. The average age of the students was 26.5 years old with a minimum age of 22 and a maximum one of 37. The experiment procedure was as follows: *(1) Introductory talk (10 minutes):* at the beginning of the experiment a short introduction was given by the ISR course lecturer. *(2) Online learning session (45 minutes):* "Document Classification" as one of the main topics of ISR course has been chosen to formulate the online learning material of the experiment [5]. *(3) Online testing session (15 minutes):* The knowledge that was gained by the student from the last session was assessed in this session. *(4) Break:* (15 minutes). *(5) Online reference answers preparation (15 minutes):* During this session, the students were asked to prepare reference answers for the questions 1, 2 and 5 with a confidence value for their estimation for their answers quality. *(6) Online peer assessment session (45 minutes):* in this session the students used their reference answers from the last session to peer-assess the others answers from the online test session. For each answer, the students were asked to mark the answer by special tags for highlighting, underlining or changing to italic. Underlining some parts of the answer means that they are correct, where highlighting them means that they are wrong, and changing them to italic means that they are irrelevant. A mark should also be given by the student for the answer from "0" (very poor) to "10" (very good). *(7) Experiment questionnaire (10 minutes):* the students were asked to fill in a questionnaire that diagnoses their impressions about the assessment activity of its three parts self-directed, online test and the peer-assessment one, as well as the usability of the web-based assessment prototype and their suggestions for further enhancements and notes. *(8) Results delivery:* students' answers and performance were analyzed and a final grade was been sent to them by e-mail.

3 Results Analysis

In this section the results gained from the students' questionnaire will be analyzed and presented. Matters such as, students' knowledge acquisition, students impressions about the online peer assessment and the usability of the tool were the main sections of the questionnaire.

From the students' point of view, their basic knowledge in the subject before the experiment was with a mean value of 2.56 (σ = 1.4) where ("0" represents complete disagreement and "5" represents complete agreement), where the knowledge gained from the online learning phase was with a mean value of 3.65 (σ = 1.05). According to the questionnaire, preparation of reference answers has supported the students to get better knowledge in the subject domain with a mean value of 3.26 (σ = 1.29), where the knowledge that they had gained from the peer assessment task was with a mean value of 3.07 (σ = 1.24), rather than these two tasks, the task of candidate answers evaluation had supported the students to get better understanding of the subject details with a mean value of 3.56 (σ = 1.22). Furthermore, students had used the course content during the peer assessment task with a mean value of 2.52 (σ = 1.74). Fig. 1, shows the results for the students' self estimation of knowledge acquisition from the overall experiment.

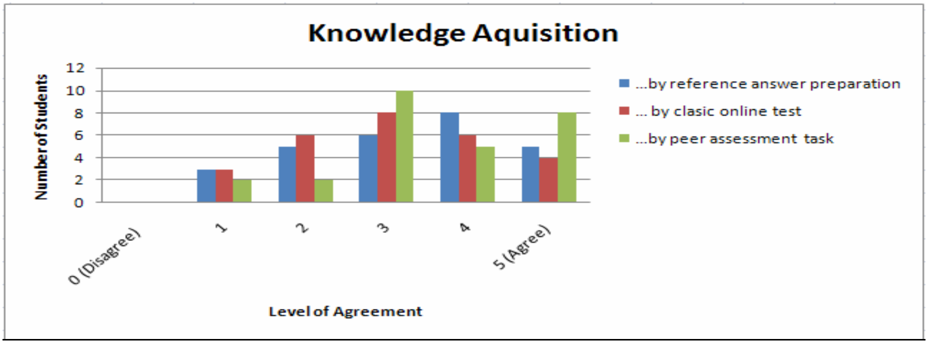

Fig. 1. Students' self estimation of knowledge acquisition in peer-assessment experiment

By analyzing the students' impressions on the peer-assessment as part of a modern learning settings and according to the questionnaire, students like peer-assessment as part of the learning activity with a mean value of 2.74 (σ = 1.51), where they recommend it to be part of the performance grading with a low mean value of 1.56 (σ = 1.45), or even as a part of the future learning settings with a mean value of 1.85 (σ = 1.32). Further Details are presented in Fig. 2.

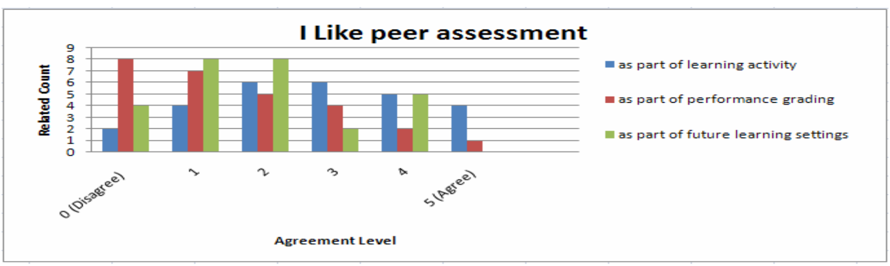

Fig. 2. Students' Impressions on peer-assessment in modern learning settings

To get better idea about the usability of the tool, students were asked in the questionnaire about their impressions on the tool functionalities and usability. According to the questionnaire, the students' impressions on the overall tool was with a mean value of 2.56 (σ = 1.25), where their opinion about the online test phase was with a mean value of 2.63 (σ = 1.21) and their impression of the pear-assessment part was with a mean value of 2.33 (σ = 1.36). We also asked them about their expectations

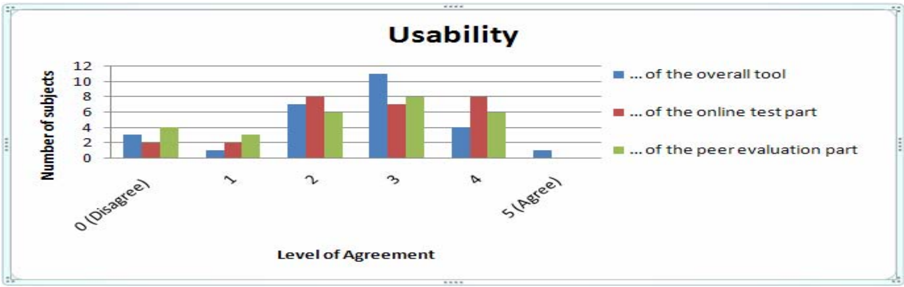

Fig. 3. The students' impressions on PASS usability

about the maximum period of time in minutes for the peer-assessment parts and their suggestions were with a mean value of 45.33 minutes ($\sigma = 28.31$), where the time for this part in the real experiment was 45 minutes. Fig. 3, shows the students' impressions on the usability of PASS.

4 Conclusions

In this paper, we have addressed an enhanced approach for a peer-assessment system. A prototype for this system were developed, and used to conduct an experiment. The experiment consisted of four main phases: online learning phase, online test, reference answers preparation and online peer-assessment of candidate answers. The software has been designed with marking possibilities to facilitate the evaluation process of candidate answers. 27 students participated in the experiment, as well as 5 tutors participated in the fourth phase to evaluate the answers collected from the students. The students were asked to fill in a questionnaire about their impressions on the overall experiment. According to this questionnaire, students gained new knowledge during the four phases of the experiment; they also recommended using such modern types of assessment as parts of the learning process; and they also suggested different enhancements based on their impressions on the usability of the system.

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Global Connections for Lasting Impressions: Experiential Learning about TCP

Colin Allison, Alan Miller, Iain Oliver, and Thomas Sturgeon

School of Computer Science University of St Andrews,
St Andrews, Fife, KY16 8SW
{ca,alan,iao,tommy}@cs.st-andrews.ac.uk

Abstract. “Tell me and I forget, Show me and I remember, Involve me and I understand”. This paper discusses the motivation for, and design of, a learning resource which allows students to explore the Transmission Control Protocol (TCP). TCP is responsible for transporting over 80% of the traffic on the Internet – all web and e-mail for example – and in addition is the primary means of achieving Internet congestion control. TCP is therefore core to modern life. It is a protocol under constant study with a view to evolution, and it is incumbent on all ICT curricula to provide education at appropriate levels about its dynamics, strengths and weaknesses. There are no shortages of good textbooks which provide information on TCP, but these are no substitute for experiential learning in order to provide a lasting understanding. The TCP Live learning resource allows students to explore the behavior of TCP on the global Internet, and see the wide variety of conditions that the protocol has to cope with, thereby extending their viewpoint outwith the limited scope of their own institutional firewalls.

Keywords: TCP, Exploratory Learning, PlanetLab.

1 Introduction

The Internet is now taken for granted as a core part of everyday life. Consequently, learning about Internet protocols is growing in importance as a topic of study and is increasingly relevant to many aspects of a learner’s daily existence. TCP, the Transport Control Protocol, is a core Internet protocol, responsible for providing reliable end-to-end communication for application-level protocols such as HTTP and HTTPS (Web), SMTP and IMAP (e-mail). In addition, TCP is almost solely responsible for providing congestion control within the Internet. Without congestion control the Internet would not function. Although TCP is an essential part of any Computer Networking educational program there are barriers to providing adequate learning experiences with TCP: the subject can appear dry and dominated by the memorization of obscure details and the deciphering of arcane diagrams; the speed at which modern networks operate preclude direct observation; the perspective on live connections offered within an academic setting are usually limited by the learner’s location and institutional firewalls. So, many features of the protocol which have evolved to deal

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with the highly varying conditions across the global Internet are rarely brought into play for learning purposes.

Today's Computer Science graduate is expected to have a deep understanding of modern networking technologies, protocols and applications. While there are several excellent networking textbooks available, such as [1-3], experiential learning is essential to complement the didactic approach which features these types of textbooks, alongside lectures, tutorials and discussion groups. The notion of experiential learning is in line with a socio-constructivist pedagogic theory in that it seeks to foster knowledge construction rather than facilitate information transfer.

One approach to making the subject interactive is to include practical programming components and combine this with tools that allow the observation of packets as they are sent and received. This has the limitation of introducing a steep learning curve to master the relevant programming skills thereby limiting the coverage of the subject that can be achieved in the busy curriculum.

The approach adopted for this work was to build a user-friendly system which allows learners to configure, deploy and explore the behavior of TCP connections, locally and globally. The user chooses two end points supported by the system and configures a connection. Packet headers are monitored and used to build a model of the TCP connection. This is saved and presented to the learner through an interactive graphical interface that facilitates observing the connection as it developed from many perspectives.

Our approach to supporting experiential learning in the curriculum allows staff to demonstrate specific scenarios in didactic situations, but can equally well motivate student-centered learning through engaging experimental facilities. This can be useful in a variety of learning contexts – in the lecture room, in a supervised laboratory, in a distance learning course as a part of a series of prescribed tasks, and informally by learners, anytime, anywhere. Lasting understanding of a topic rarely comes from one or two participations in learning situations – the line between puzzlement and understanding must normally be crossed on many occasions and one of the most important features of TCP Live is that it can be visited and re-visited as often as the learner wishes.

2 Related Work

Previous work by the authors on exploratory learning for computer networking [4] includes TCP View and the WiFi Virtual Laboratory. TCP View [5] is a "one stop" informational site for TCP education. It features many animations and provides alternative visualisations of the same protocol exchanges and features. TCP View uses Flash, Java applets and VRML (Virtual Reality Modeling Language). ALWPO (Active Learning with Planetary Objects) Explore-v4 [6] is a "packet-a-time" interface to IP that enables learners to construct, send, and observe the results of sending individual IP datagrams, all through a web-based GUI. Explore-v4 can be used to send individual TCP segments, encapsulated within IPv4 datagrams, but this can only provide a very limited view of the protocol in action as TCP is a timer-based connection-oriented protocol which continually adapts its behaviour to the prevailing Internet conditions – this cannot be achieved through manual intervention. TCP Live, described in this paper, was designed to complement the TCP View web site and exploits the same underlying framework as Explore-v4, ALWPO. Mark Holliday's courseware aids [7] are Java applets which animate core concepts in networking and allow users to input key parameters. JASPER [8] allows users to add their own new protocols through editing a finite state table in the Java source code and recompiling. The companion web site for Kurose and Ross's popular textbook [1] provides facilities similar to TCP View. The WiFi Virtual Laboratory [9] combines interactive information content of the type found in TCP View with a web-based system that uses ns2 [10] as the simulation engine.

3 TCP: The Transmission Control Protocol

TCP is a moderately complex protocol, providing reliability and simplicity to the application-level protocols which use it and providing congestion control to the underlying network layer. It is a full-duplex, connection-oriented protocol, built on top of the underlying best-effort, unreliable, Internet Protocol. During the life time of a TCP connection each end goes through a series of state transitions that are known as TCP's *Macro State*. These transitions permit the reliable setting up and tearing down of connections. There are numerous pathways through the state transition diagram (which is reproduced in most computer networking textbooks), and students often have difficulty in understanding the different interactions that are possible. A separate *Micro State* is used to control the actual flow of data within a connection (i.e. when the Macro State is "Established"). This does not have a formal state transition diagram but is rather represented by the values of various timers and other parameters, many of which are hidden from network monitoring technologies and can only be inferred. These parameters and their changing values are often open to misunderstandings by students, based on static textbook examples. There are numerous aspects of TCP data transfer that it is important for students to understand:

- the finite read and write buffers that are shared with the application
- dynamically adaptable sliding windows
- bandwidth utilization and fairness
- dynamic estimates of round trip time and variance in round trip time used to adjust retransmission timers
- congestion control and avoidance mechanisms.

There are a number of factors that affect the way these aspects interact and the behavior that is produced by a TCP connection. For example, the type of application is important. A TCP connection serving a bulk transfer application will have very different characteristics to one serving a low bandwidth interactive application. Similarly, the characteristics of the network path, for example the round trip time and the physical bandwidth available, will affect the efficiency achievable for a particular flow-controlled window size. The effect of packet loss and duplicate acknowledgements on the micro state is of particular importance. The quantity and behavior of competing traffic will also have significant consequences.

These are the reasons that motivate the design of a learning resource which allows students to explore the behavior of TCP at different points within its parameter space across a wide range of network conditions.

4 Planet Lab

Internet research scientists face similar problems to networking educators when observing and measuring internet traffic and carrying out experiments in that there are recognized limits on the usefulness of simulated networking environments: “Simulating how the global Internet behaves is an immensely challenging undertaking because of the network's great heterogeneity and rapid change. The heterogeneity ranges from the individual links that carry the network's traffic, to the protocols that interoperate over the links, the “mix” of different applications used at a site, and the levels of congestion seen on different links” [11]. At the same time it is difficult to use the real Internet without interference from local security policies and their implementation in terms of firewalls. Assuming that the firewall problem can be overcome (a big assumption) there is then the further challenge of finding “friendly” nodes which can act as traffic end-points, either sources or sinks, elsewhere in the Internet. So, how can access be provided to a wide range of real network conditions? Planet Lab [12] was designed to address this need. By definition a Planet Lab node is not fire-walled by the host institution – all security is handled by the Planet Lab consortium and the customized operating system that runs on a node. In practice this means that a participating site must have institutional agreement to participate in the experimental network, but the fact that there are clearly stated terms of use and an international consortium of respected researchers involved makes this non-commercial agreement more likely to be acceptable. At present there are approximately four hundred Planet Lab sites spread across the world.

5 The ALWPO Framework

ALWPO (Active Learning with Planetary Objects) provides a framework for the exploitation of Planet Lab for educational purposes. Its key features are:

- a means of choosing one or more Planet Lab nodes, which are dynamically checked for their availability, through a point-and-click Google Maps interface, (see Fig. 1). Note that only a small number of the available Planet Lab sites are presented to the user,
- a web-based user interface and intermediary controller which communicates with lower-level socket and packet filter code on the selected Planet Lab nodes.

The learner can therefore interact with lower levels of the protocol stack e.g. IPv4, ICMP, UDP, TCP, without requiring the experience and expertise that is necessary to program raw sockets and packet filters.

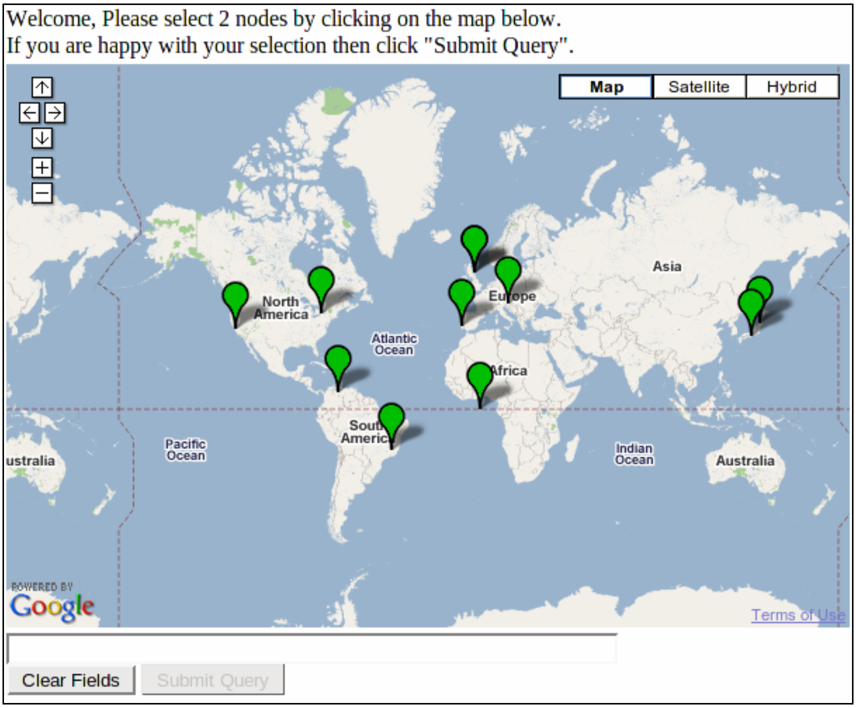

Fig. 1. ALWPO Interface for selecting nodes

There are currently two learning environments which utilize ALWPO, Explore-v4 and TCP Live. As mentioned in Section 2, Explore-v4 provides a web-based GUI that allows users to manipulate IPv4 datagrams on a packet by packet basis. As such it only provides limited support for observing TCP in action.

6 TCP Live Architecture

The TCP Live architecture consists of four components. The user's client software (User Client) is downloaded via a web browser using Java Network Launch Protocol onto the user's machine. The other components are software daemons distributed across the web server and the Planet Lab nodes (see Figure 2). The User Client provides web-based anytime / anywhere access. It communicates with the Node Server, Connection Servers and the monitor. It builds a model of the TCP connection and provides interfaces for its exploration. The Node Server provides reliable access to Planet Lab nodes via the ALPWO framework. The Connection Server software runs on Planet Lab nodes. It receives and services requests from user clients to set up connections. The Monitor observes TCP packets from a connection under observation, extracts packet headers and efficiently communicates with the user client. The User Client can read packets from the Monitor or various types of file. The Node Server

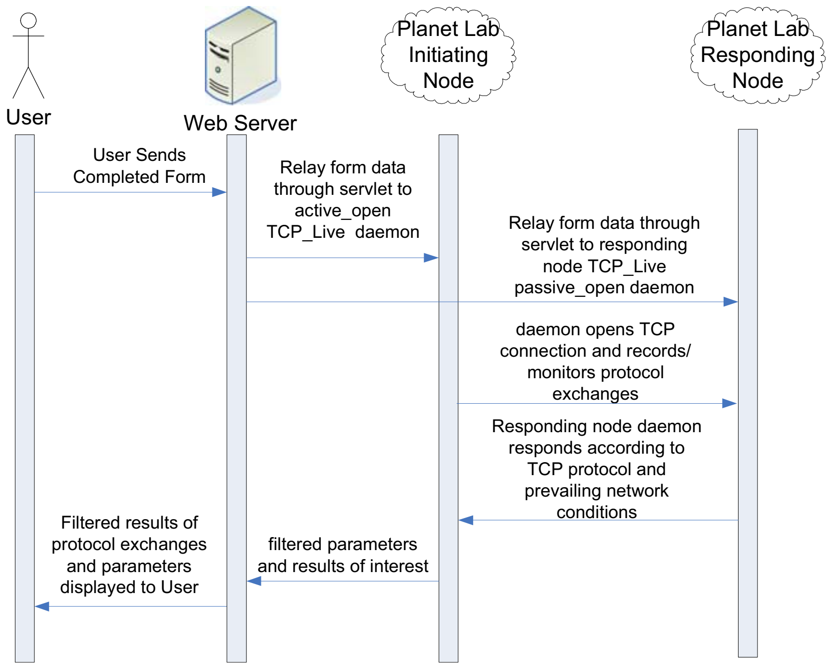

Fig. 2. TCP Live component interaction overview

allows User Clients to choose Planet Lab nodes to set up associations with. A TCP Live Connection Server runs on a Planet Lab node. A User Client may set up an association with a Connection Server.

The Connection Server will then accept connections requests from the User Client program, which may specify a wide range of configuration information. The User Client communicates directly with Connection Servers located on both the client and server ends of the connection being monitored.

The Monitor runs on a Planet Lab node. When it receives a connection it selects a port to listen on and sends this to the User Client, and also sends any packet to or from this port to the User Client. A public domain packet filter library, libpcap, is used to capture packet information including addresses, time stamps and the TCP header. The checksum for the packet is calculated and all of this information is packaged and sent to the User Client.

7 TCP Live User Interface

The user can choose to create a new live session or open an existing one. Once a session is loaded the interface provides a variety of views.

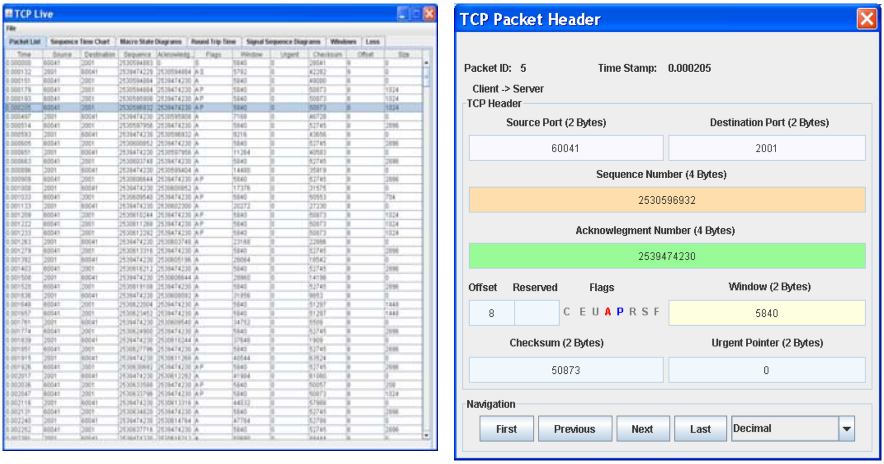

Fig. 3. The basic list of packets (left) and a detailed header selection view (right)

Figure 3 shows the initial packet list view. If a particular packet is selected a detailed representation of the packet header is displayed.

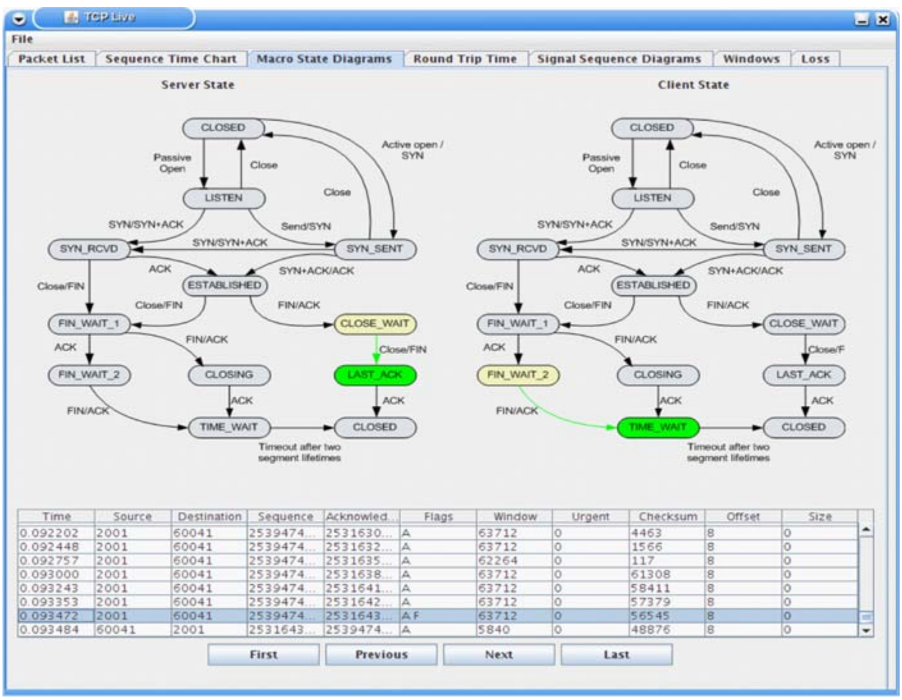

Fig. 4. The Macro State diagrams associated with a particular packet

The second tab (not shown) displays a sequence diagram of the progress of the connection. The times and sequence numbers of packets are recorded and used to calculate the relative time and sequence number of each packet from the client to the server.

Figure 4 shows the third tab, "Macro State" view. This is based on a much published state diagram that is included in static form in most textbooks. TCP Live brings it to life, showing which states the connection is in as each segment is selected. One state transition diagram is shown for each end of the connection. A frame-by-frame facility is also included so that the user can step through the state transitions.

The fourth tab (not shown) displays the Round Trip Times (RTT) and associated variable values. This allows learners to observe the relationship between each of these variables. In particular the effect of including variance in the Retransmit Time Out can be brought home clearly when observing graphs of connections with high and low variations in RTT.

Signal Sequence diagrams, as shown in Figure 5, are a common means of displaying protocol message exchanges and can be found, in static form, in most text books. Gaps in the sequence numbers and their acknowledgements are taken as indications of

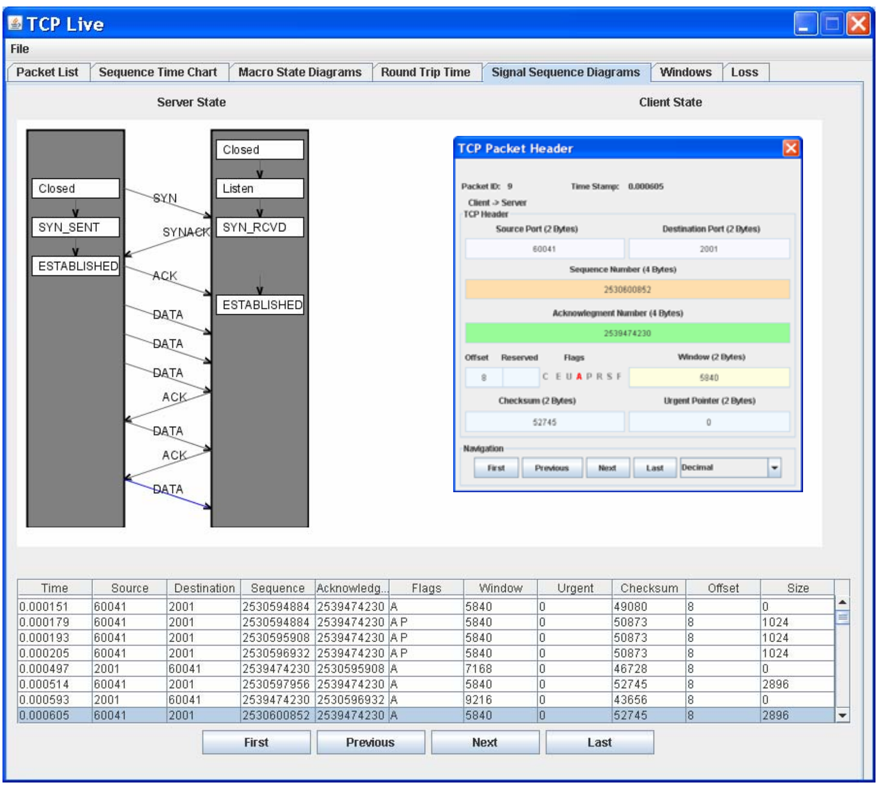

Fig. 5. Signal sequence diagrams can be stepped through for detailed examination

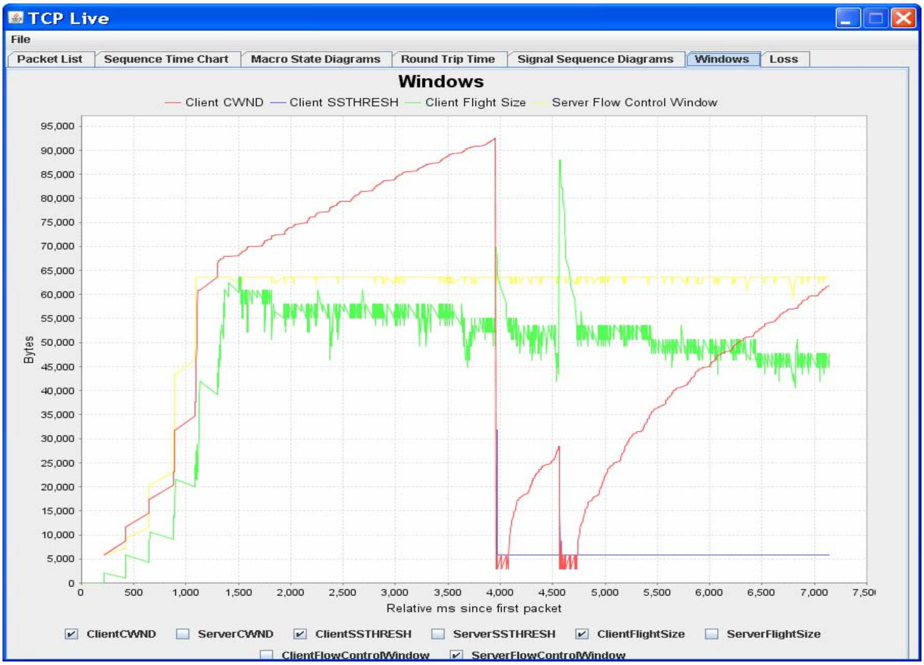

Fig. 6. The User Interface with the Windows tab selected

loss. Loss is calculated by recording the largest sequence seen in order and the largest sequence number acknowledged as well as all of the sequence numbers seen that are out of order. Note that this view incorporates both the packet list and the option for detailed header inspection.

The Windows view shown in Figure 6 depicts the states of the windows that control the number of packets in flight. To calculate these values the congestion control system of TCP is simulated by the client i.e. the values are inferred from the visible connection parameters. The congestion window (CWND) starts at two segments and is increased when packets are successfully transmitted and reduced when packets are lost. The amount that CWND is increased depends on its value and the value of the threshold. The values of CWND and threshold determine if the connection is in *slow start* or *congestion avoidance* mode. This view shows the effects of packet loss on TCP's window management algorithms. This type of phenomenon can only normally be found on global Internet connections. Campus and academic networks do not typically exhibit packet loss.

The final tab shows a summary graphic view of packet loss rates over the lifetime of the connection.

In summary the learner can set up and deploy a live connection and then examine its behaviour from multiple views of the trace of that connection.

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The Pedagogical Dimension of Metadata for Learning Resources: The POEM Model

Serena Alvino[1], Paola Forcheri[2], Maria Grazia Ierardi[2], and Luigi Sarti[1]

[1] ITD-CNR, Via De Marini 6,
16149 Genova, Italy
{alvino,sarti}@itd.cnr.it
[2] IMATI-CNR, Via De Marini 6,
16149 Genova, Italy
{forcheri,marygz}@ge.imati.cnr.it

Abstract. This paper focuses on the pedagogical dimension of metadata for learning objects (LO). Devising a pedagogical metadata proposal suitable for different target users is still a hard challenge. In order to contribute towards this endeavour, we designed and evaluated an extensible model where alternative sets of metadata descriptors can be chosen, depending on the pedagogical role of the LO. We called it Pedagogy Oriented Educational Metadata (POEM) model. This paper presents the main lines of the POEM model, discussing the results of its latest validation with 120 pre-service teachers attending the Specialisation School for Upper Secondary School Teachers of the University of Genoa during the a. y. 2007-2008.

Keywords: pedagogical issues; pedagogical modelling of learning resources; learning object; educational metadata.

1 Introduction

Nowadays teachers and instructional designers can rely on a considerable abundance of learning objects (LOs), i.e. digital resources that can be reused to support learning [14]. Nevertheless, to be effectively retrieved and reused by them, LOs should be endowed with educational metadata providing a clear pedagogical picture of the material and able to capture, at least to some extent, the parameters that LOs' prospective users adopt in their practice to search for digital educational resources. As a matter of fact, the description of the educational needs that inspired the design of a LO, together with the illustration of the underlying assumptions on learning and of the epistemological and pedagogical approaches to the content, significantly supports the retrieval of potentially re-usable LOs and favours the reflection on their adaptability to the situation at hand. However, it is generally recognised that present metadata standards, like IEEE LOM [9], have a limited capacity to offer this picture according to the view of the education world. In addition, in LOM based application profiles pedagogical metadata elements are almost never mandatory, thus they are rarely filled in [5]. To these problems, that mostly derive from the technological context in which the LO

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technology was conceived and developed, we have to add the difficulty of identifying a standard set of metadata that balance essentiality needs (to limit the effort of the production) with precision requirements (to facilitate the retrieval of a resource) [4]. These issues form the basis of the studies that analyse educational metadata according to a pedagogical point of view. For example in [10] indications are formulated, on the basis of the psychology of learning, about possible types of LOs and ways to expand metadata in order to support meaningful learning. With an education practice orientation in [13] some modifications to LOM are proposed. Approaches to the evaluation of pedagogical metadata, so as to verify their quality, have also been worked out [7]. The need for metadata application profiles to include pedagogical descriptors aimed at meeting educators' needs has also been outlined. An example is the *Gateway to Educational Materials* (GEM, http://thegetaway.org), a project of the US Department of Education based on the Dublin Core Metadata Standard (http://www.dublincore.org). GEM introduces a metadata application profile for describing educational resources in a semantically rich way; with an accompanying set of controlled vocabularies, it forms the basis for the proposal formulated by EdNA (Education Network Australia http://ww.edna.edu.au), a network of the Australian education and training community. A further example is the *TLF LOM Application Profile* v2.2 (http://www.thelearningfederation.edu.au) promoted by Australia and New Zealand Ministries of Education [6].

Anyway, it has been observed that the expressive power of these application profiles is often unsatisfactory with respect to the underlying educational paradigm mainly because they lack of a learning-related vocabulary to help users describe type of learning, objective and context [12]. These proposals show the complexity of devising a pedagogical metadata model suitable for a wide variety of user communities, as these are usually characterised by different languages, backgrounds, motivations and objectives (for example, teachers of various countries, or pertaining to different education levels and/or systems, with specific objectives and educational approaches). These problems call for a user-centred approach in devising a pedagogical metadata model that is suitable to spread the LO culture in the schools. To this purpose, a preliminary analysis of the kinds of LOs that users employ in their practice is required, so to provide conceptual and technical tools for the selection of LOs as close as possible to the process teachers usually adopt in their work. With these concerns in mind, we elaborated an initial proposal for pedagogical metadata that is characterised by: 1) the introduction of specific metadata elements representing different typologies of LOs according to the role they are intended to play in the learning process and their intended-end user; and 2) alternative sets of metadata descriptors depending on these typologies. Then we adopted an iterative approach to the evaluation of the adherence of the proposal to the needs of a number of communities and we derived from it an extensible model for pedagogical metadata, called *POEM - Pedagogy Oriented Educational Metadata*. The model and its conception are presented here, together with the results of a recent validation process carried out with 120 prospective teachers attending the Specialisation School for Upper Secondary School of the University of Genoa (Italy) in the a. y. 2007-2008. We observe, preliminary, that the model, focusing on the pedagogical aspects, is not intended to describe content-related aspects, for which we refer to international standard schemata.

2 Towards a User-Centred View of Pedagogical Metadata

The conceptual framework of POEM model is based on two main assumptions. On the one hand, we observe that teachers, in their practice, usually take advantage not only of LOs directed to students, but also of models that represent suggestions, work plans, best practices, etc., developed by their peers. These digital resources directed to teachers can be considered LOs as well [14], because they can be reused to structure an effective learning experience in a specific educational context [2]. These LOs allow to carry out innovative classroom activities and can contribute to reinforce the teachers' professional competencies. This idea led us to base our metadata model on two main sets of educational resources representing two main intended-end users categories: *Student-oriented* LOs and *Teacher-oriented* LOs. On the other hand, LOs can be classified depending on the role they are intended to play in the learning process. We observe that teachers produce/reuse two main kinds of LOs: 1) modules, specifically designed for supporting or organizing a learning process, which pursue educational objectives and embed a pedagogical approach to them, namely *Structured LOs*; 2) auxiliary materials enriching a learning process as reference materials, which do not embody an explicit educational structure nor include a specific pedagogical orientation (i.e. FAQ lists, study guides, annotated bibliographies, etc.), and have a general-purpose or a context-related function, namely *Functional LOs*.

The above distinctions shouldn't be considered as absolute: they refer to the intended pedagogical role according to which the author created the LO or the indexer describe it. For this reason, POEM supports multiple descriptions of the same LO according to different perspectives of use. *Functional LOs* can be provided to both students, for reference aims, and teachers to build a structured learning path or material; thus, they belong to the intersection of the *Student-oriented* and *Teacher-oriented* resource sets. At the outside of this intersection lie *Structured LOs* devoted either to students or teachers (see Fig. 1).

The *Teacher-oriented structured* set of LOs includes schemata, scripts, metamodels, etc. Depending on the kind of support provided to teachers, on the level of abstraction from the context and on the level of formalization, these LOs can be classified as follows: 1) *Pedagogical patterns and the like*, which model the solution to frequent and well-known educational problems referring to specific strategies or techniques, without contextualizing it in a specific knowledge domain; 2) *Lesson plans*, which represent in plain natural language the instantiation of this solution in a specific knowledge domain, in terms of objectives, strategies, resources, and so on, 3) *EML Units of Learning,* which model the flow and the structure of modules or entire courses by using formal languages (EML – Educational Modelling Languages; for instance the IMS-LD specification http://www.imsproject.org/learningdesign), on the basis of their embedded methods, proposed activities, the involved roles, services and resources. Conversely, the *Student-oriented structured* set of LOs can be classified according to the pedagogical approach they embed, in order to provide criteria to assess the educational applicability of the LO in the specific user context. When creating a *Student oriented-structured LO* a teacher normally relies on precise assumptions on the learning process; accordingly, we distinguish among three main typologies of LOs: a) *Directed-by-teacher LOs*, which foster a gradual approach to learning contents through the guidance of a teaching agent; b) *Problem-based autonomous LOs*, which support autonomous exploration of learning contents and involve the student in a shallow-structured learning path; c) *Mixed LOs* which are aimed at covering a comprehensive proposal on a topic, and integrate the other two typologies. This conceptual framework has been translated into a metadata schema that is briefly outlined in the following Section 3.

3 Realization

The POEM model integrates descriptors from the main international metadata standards with new ones aimed at identifying the context of use, the educational features, the structure and the learning approach of the LO. More precisely, our proposal is articulated into five categories of metadata: Pedagogical Model, General, Audience, Educational Features and Annotation (see Fig. 1).

The *Pedagogical Model* category constitutes the characteristic feature of POEM. LOs taxonomies identified in the conceptual framework have been brought back into the *Type* element's vocabulary of values: in particular, three values represent *Teacher-oriented structured* LOs (*Pedagogical Design Patterns, Lesson Plans, EML-Units of Learning*), one value describes *Functional* LOs and one value stands for *Student-oriented structured* LOs (*Student oriented - Structured*). The *Type* element is mandatory and for any given LO it can take only one of the values of its vocabulary. When defining the other elements of the *Pedagogical Model* category, we argued that the same set of descriptors could hardly characterize all types of LOs. For example, the didactic strategy is a key-element when describing any type of structured LO; however, it is scarcely useful for *Functional LOs*, which can be better described on the basis of the resource typology (*ResourceType*, e.g., set of data, graph, etc.). Therefore, this category includes mutually exclusive sets of descriptors, to be used in dependence of the actual value of the *Type* element. In particular, all structured LOs can be described according to the didactic strategy they embed, the existence and type of the proposed activity, and of the (self)-assessment material. Moreover, this category includes a descriptor, *Subtype,* that allows a further distinction between *directed-by-teacher, problem-based autonomous* and *mixed* LOs.

The *General* category includes two descriptors that correspond to the LOM 1.3 *General.Language* and 5.11 *Educational.Language* elements respectively.

The *Audience* category describes the characteristics of the intended user of a LO (in case of teacher-oriented LOs this is the final user, i.e. the learner). It includes elements, similar in their meanings to the ones of other proposals (e.g., EdNA), aimed at describing the sector and level of the target students. Differently from other proposals, this category also comprises elements aimed at describing prerequisites that refer not only to the content domain but also to the general competences that should be mastered to successfully deal with the LO.

The *Educational Features* category describes features such as the *Time* estimated necessary for the fruition of the specific LO (analogously to the LOM 5.9 *Typical learning time* element) or the *Fruition Mode* (distance, presence, blended). Other elements in this category describe the nature of the *interaction* activated by the LO, the most suitable physical *environment* to foster its effective fruition, the *educational goals*. Differently from other proposals, the POEM model considers not only the

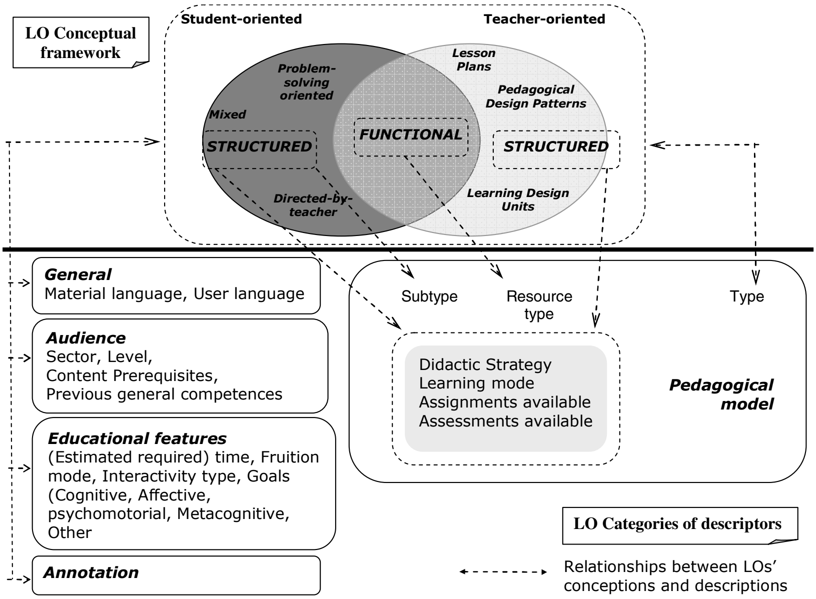

Fig. 1. Relationship between the LOs conceptual framework and the POEM model

cognitive domain of Bloom's taxonomy [3], but also the psychomotor and affective ones. Moreover, the model provides descriptors for meta-cognitive goals and for specific school goals. Most of these elements are intended as optional, i.e. usable only when they are useful to reveal peculiar characteristics of the described LO.

The *Annotation* category corresponds to the LOM *Annotation* category.

The model is schematised in Figure 1. For the technical details we refer to [1].

From a technical point of view, to easily adapt both element names and vocabularies to specific contextual requirements, currently a two-layer architecture acts as a namespace schema [8, 11] for a number of application profile schemata, each one tailored and optimized for a particular user community. The application profile draws elements from the complete model, refines their definitions and adapts vocabularies, but rarely creates new elements (e.g. competencies targeted by the LO – see EU *Share.TEC project* application profile of POEM http://www.share-tec.eu/). Terms and vocabularies are translated, when needed, into the community native language. This process is not free from hindrances and pitfalls, and calls for the involvement of representatives of the user community in a participative effort.

4 The Latest Validation Process

As already mentioned, POEM emerges from the progressive evolution of an initial proposal for pedagogical metadata, driven by users' needs elicited in various validation processes [2]. We tested the effectiveness and the acceptance of our initial proposal with some groups of prospective users, each group belonging to a different educational field and thus characterized by different needs, constraints, priorities and jargons: professors and researchers who are experts in e-learning methodologies, M. S. students attending a basic course in “E-learning and knowledge management”, vocational trainers, primary school teachers, etc. The outcomes of these validation processes induced some modifications and enhancements to the proposed model, which was then called POEM and evaluated with another specific target, i.e. prospective teachers attending the ‘Multimedia in education’ course of the Post-graduate Specialisation School for Upper School teachers of the University of Genoa (120 participants) in the a.y. 2007-2008. The participants to this course normally have already some experience (more than 1 year) of teaching in secondary schools. Thus, the kind of experimenters can constitute a good occasion to analyse the adequacy of our choices to (novice) teachers’ views of the material. The cultural backgrounds of the participants vary from humanities to sciences. Typically, all of them are new to the concept of LO, and their previous knowledge and experience on technology enhanced learning is quite limited. The course aims to guide participants to actively reflect on the pedagogical implications of the use of multimedia in the school practice. In the following, we use indifferently the terms participant, (prospective) teacher, and experimenter.

To perform this validation process, participants preliminarily had a lesson on LOs, with particular reference to metadata, and a presentation of POEM. Then they were asked to carry out an indexation activity. Firstly students were provided by ten LOs, some produced in the previous editions of the course, some retrieved in online repositories, selected on the basis of the different backgrounds of the participants. They were asked to analyze two of them, write down a comment on them and then index them. Moreover, they had to write down some notes about the indexing activity. The task was supported by a web-based tool, which also provided a guide to POEM with the overall description of the model and a context-sensitive glossary. At the end of the work, prospective teacher filled in a questionnaire focusing on the expressive power of POEM. The questionnaire included both closed and open questions, the latter aimed at allowing the participants to briefly motivate their answers. The questionnaire analysed the following issues: (a) Capability of the POEM model to represent the main pedagogical features of a material; (b) Effectiveness of the selector *Type* in supporting teachers when selecting resources in their every day practice; (c) Capability of the POEM model to express pedagogical features via concepts and language familiar to teachers; (d) Manageability of POEM by teachers as regards number and organization of the information; (e) The usefulness of the glossary.

4.1 The Main Results

The validation process was analysed on the basis of both the results of the questionnaire and of the indexing activity.

Ninety-eight participants answered to the questionnaire. The results (see Table 1) seem to indicate that our proposal is a quite valuable attempt to describe a material from a pedagogical point of view. In fact the 95% of the participants argued that POEM captures the educational features of a LO; about the 88% stated that the metadata proposed are useful to search LOs and only the 13% would add other descriptive elements. Besides these positive results, the answers to the open questions also suggest a number of issues to be further deepened. Some experimenters suggested to add metadata to express the prevailing learning style promoted by a material, an aspect not considered in POEM. Other relevant observations regard the need of describing: 1) different levels of extra-school education, 2) the opportunity offered by a LO to carry out interdisciplinary work; 3) the ease of use for the teacher.

Some metadata are considered ambiguous (a number of participants observed that in cases like movies, demos, and so on, it is not clear if the *Time* element refers to the length of the product or to the time needed by the practical application in the school context) or redundant (as regard the *Interactivity type* descriptor some experimenters found it quite difficult to distinguish among its values, especially in case of material with low granularity; the items *Resource type* and *Didactic strategies* were considered partly redundant). Moreover, a number of participants objected that, in their case, for the metadata *Fruition mode* all admissible values were applicable, thus limiting its expressive power. As to the effectiveness of the selector *Type,* the 95% of participants argued that its five values represent, from a methodological viewpoint, all possible LO types. In addition the choice of categorising LOs in these five disjoint typologies was in general found effective (79% of positive answers) as (experimenters said) it forces to reflect on the nature of a LO. Some experimenters however found this feature limiting. Someone declare that, in a number of *Student oriented LOs*, the two typologies *Functional* and *Structured* were integrated; others say that their differences mainly depend on the use of the module, rather than on their nature. For example, a module aimed to guide students to recognise forms in a picture with a discovery-based approach was by some participants judged *Student oriented-Structured* and *Problem-based* while some others considered it *Functional.* Finally, almost all participants considered the glossary a very precious aid and declared that, without such support, it would be too difficult to index the LOs.

The results of the indexation activity confirm the above results. In some cases the selected values for *Time* element differ prominently as to the same LO. By analysing the values of the other metadata, we observed that the value assigned to *Time* is related to the metadata *Audience* and to the metadata *Type.* Similarly, the intended context of use determines the time. Different values for *Type* too have been selected for some LOs. We observed that in some cases this choice was interrelated with the one concerning the *Audience* metadata elements. For example, a multimedia tutorial about the history of the English language has been described as *Type=Functional (reference material)* for *Audience= Upper secondary school* and as *Type=Student oriented-Structured* for *Audience= Lower secondary school.* In our view, this means that sometimes the value of *Type* is chosen depending on the intended use of the material. Confusion is also generated by very rich LOs, which include references, hints for deepening a topic and, at the same time, are endowed with a clear pedagogical structure.

4.2 Results, Discussion and Model Refinement

The results of this validation process allowed us to infer some overall indications and gave hints to further improve the model. Moreover, they highlight the difficulties to align teachers' points of view when describing a LO, thus confirming the hard challenge of devising a pedagogical metadata proposal suitable for different target users, operating in different educational contexts. As regards POEM's metadata elements, the latest validation process reveals some ambiguities in the choice of the names and the lack of one or more items representing the different learning styles of students. In addition, according to the sample of prospective teachers, some vocabularies contain similar or overlapping values, that in teacher practice normally are not distinguished; this fact implies an extra, often useless effort in classification. As we did with the previous validation processes, actually we are integrating these suggestions in a revised version of the POEM model, so to progressively mould it on the needs of a variety of prospective users and to pursue generality and flexibility. Moreover, we are addressing the main issues pointed out by this recent validation process (listed below).

Table 1. Appreciation of the POEM Model (closed questions; total respondent=98)

		YES	NOT	No Answer
Model	Are the educational feature of a LO captured?	95%	4%	1%
Metadata	Are metadata names clear?	78%	22%	0%
	Would you add other metadata?	13%	85%	2%
	Would you eliminate some metadata?	24%	73%	2%
	Are metadata proposed useful for searching for LOs?	88%	10%	2%
Metadata *Pedagogical Model.Type*	Do its values represent, from a methodological viewpoint, all possible LO types?	95%	5%	0%
	Is it effective to have to choose <u>one and</u> <u>only one</u> value for describing LOs?	79%	21%	0%
	Is it limiting to have to choose <u>one and</u> <u>only one</u> value for describing a LO?	45%	55%	0%
Vocabulary	Are vocabularies clear?	68%	30%	2%
	Would you add values in some vocabulary?	11%	88%	1%
	Would you eliminate values in some vocabulary?	10%	89%	1%
Glossary	Usefulness	98%	0%	2%
	Clarity	94%	4%	2%

<u>1) The intrinsic interdependencies of metadata values.</u> This issue is pointed out by the variability of the values assigned to *Time*, that seems to be dependent on the particular school level the indexer refers to. Similarly, some divergences in the choice for the value of *Type* are due to this factor. The information about interdependency is generally lost when multiple values are admitted for metadata. In our view, a possible solution to this problem consists in providing a LO with multiple indexing: one indexation provided initially by the author and further ones provided by the teachers who re-used it in their practice, possibly enriched with a brief description of the use. This opportunity, moreover, would enhance the expressive power of metadata, that could become a

vehicle to reflect the evolving interpretation of a LO. A specific validation process will be carried out to evaluate this hypothesis.

2) The difficulty of adopting the same parameters for LOs with different granularities. For example, experimenters had difficulties to choose between *Type=Functional* and *Type=Student oriented- Structured* in case of LOs with low granularity, as both components are present. Similarly, metadata like *Cognitive objectives* provide for a fine distinction that is useful only for LOs with very high granularity. In the majority of the cases, the material pursues more than one cognitive objective. We observe that the POEM model is a general model apt to cover the more wide range of granularity: it demand to the application level the management of granularity issue (the interface could provide the users with the possibility of filling-in more than one form for the same LO, so to describe it according to different perspective of use).

3) The importance of teachers' competencies and background about learning theories. Some differences arose between teachers' choices when describing the same LO can be associated to a lack of competencies in the field of learning theories. In such a way an *exploratory* strategy is mismatched with *drill and practice* exercises, conceived as games. This problem is mainly due to the overall preparation of teachers that, at least in Italy, includes analysis of learning theories only at a limited extent. Thus, its solution relies on a deep reflection of the kind of preparation should be offered to teachers, so to make them aware of present orientations in studies about learning and on the role that technology can play to support the sharing and the interiorization of educational practices and knowledge. A modification to the vocabulary related to the *Didactic Strategy* descriptor - according to this validation process - could also foster a less ambiguous interpretation of the possible choices.

4) The specificities of the LO's content or intended context. For example, some ESL (English as Second Language) prospective teachers suggested to include a descriptor about the competency level (PET, First Certificate, Proficiency and so on) addressed by a LO. Another example, drown from the literature, regards the classification of the material with respect to the subject matter. In the case of mathematics different taxonomies can be employed to classify material depending on the school level. This issue could be solved by proposing different application profiles, a solution we already discussed in [2].

5 Conclusions

The POEM model has been validated with a consistent number of teachers in initial education who revealed specific characteristics and needs that must be taken into account when proposing a pedagogical metadata model. On the one hand, the results point out that POEM succeeds in capturing the educational features of a LO, thus revealing itself as a quite valuable proposal to describe a LO from a pedagogical point of view. On the other hand our validation process confirms that LO indexing is a complex activity influenced by the educational context, the target, the pedagogical approach the indexer refers to. Providing LOs with multiple indexing reflecting their re-use, as we propose, helps to take into account a variety of perspectives, that, on the whole, give a clear pedagogical picture of the possible uses of the LO in the education practice, and singularly represent the opinion (experimented in the classroom) of a teacher. This constitutes an added value that could effectively support teachers to find out useful resources for their specific educational contexts. A next step will be to investigate if our metadata really helps learners to improve selection of LOs.

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A Parameterized Web-Based Testing Model for Project Management

Constanta-Nicoleta Bodea and Maria Dascalu

The Academy of Economic Studies,
Calea Dorobanţi, no.15-17, Sector 1,
010552 Bucharest, Romania
bodea@ase.ro, cosmicondina@yahoo.com

Abstract. This paper proposes a web-based testing model for project management. The model is based on ontology for encoding project management knowledge, so it is able to facilitate resource extraction in the web-based testware environment. It also allows generation of parameterized tests, according to the targeted difficulty level. The authors present the theoretical approaches that led to the model: semantic nets and concept space graphs have an important role in model designing. The development of the ontology model is made with SemanticWorks software. The test ontology has applicability in project management certification, especially in those systems with different levels, as the IPMA four-level certification system.

Keywords: web ontology language, metadata, testing, project management, concept space graphs.

1 Introduction

Web-based testing, a category of computer based testing [1], assures flexibility, friendly interfaces and increased accessibility. Nevertheless students and tutors are still asking for a higher level of testing personalization and for a user-centered approach. In order to define different user models, learning methods or quality requirements, multiple parameters are needed for adapting the testing to the organizational context or user profiles [2]. A technical solution for addressing the personalization issue in testing is the usage of metadata. This paper proposes an ontology model. Based on the Ontology Web Language (OWL) metadata, the model can be successfully used for developing web testing systems. OWL was considered a suitable form of metadata for testware: the choice lies in its properties [3].

2 Knowledge Base Used in Project Management Testing

In the field of project management (PM), the SinPers platform proposes a method of modeling digital content by using learning objects [4], which are explained or

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Table 1. Concepts required by C1.19 – "Start-up" competence in the PM domain

Concept Code	Concept Description
DDI	Decision of making the investment
DIP	Document for initiating the project
PRO	Project proposal
CPR	Project charter
DDP	Decision to start the project
EEP	Pre-evaluation of the project
ATP	Assigning the project

assessed by 200 concepts defined in the domain ontology. Relationships between concepts can be: hierarchical (represented by white arrows in Fig, 1(a)), dictated by logical constraints (the mandatory learning order is defined by black arrows in Fig, 1(a)) or suggested (optionally). These concepts are grouped into 46 competences, as ICB v3.0 [5] requires: a competence involves learning / proving knowledge of *n* concepts (an example is provided in Table 1).

Starting from the SinPers concept ontology, we developed a stand-alone knowledge framework for automatic test generation on web. It facilitates the tailoring of the difficulty level and the area covered by assessed knowledge, using metadata.

3 Theoretical Foundations for Knowledge Structures in Parameterized Computer Based Assessment

Each competence from the course ontology, depicted in Fig.1(a), has a threshold coefficient, which facilitates the step towards the knowledge representation of tests, as semantic networks. According to threshold value, the competence defines a set of concepts or projects a concept space graph. Each difficulty level (A, B, C or D) [5] has a corresponding threshold value, established by experts. In order to illustrate this, several stages are described.

First, the extraction of the semantic net for a certain element of competence from the course ontology means obtaining a smaller, competence oriented, net. Then, the newly created semantic net is transformed to a concept space graph: each vertex of the graph represents a concept and each link with weight $l(i, j)$ represents the semantics that concept c_j is a prerequisite for learning c_i, the importance of this semantics being given by the weight. Each vertex is further labeled with W_s (self-weight value, the relative semantic importance of the parent topic itself with respect to all other prerequisites) and W_p (prerequisite-weight value, the cumulative semantic importance of the prerequisite topics to the parent node) [6]. For example, for node DDI in Fig.1 (b), self-weight value is 0,3 and prerequisite-weight value is 0,7. Projection of concept space graph to sub-graphs of different semantic dimensions is realized

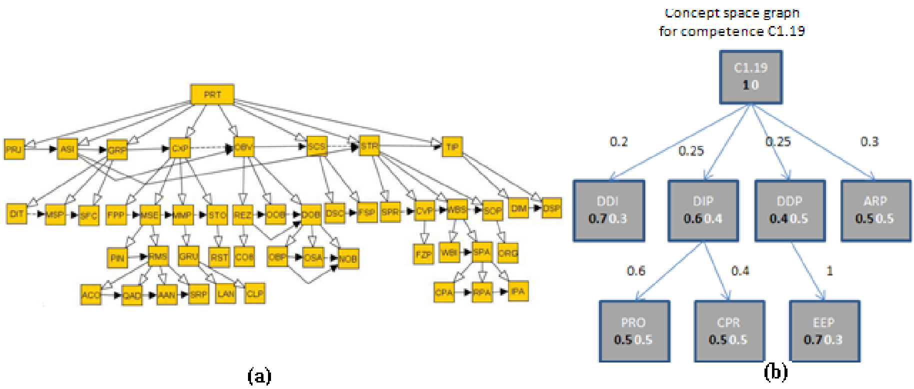

Fig. 1. Knowledge structures in the Project Management Automatic Assessment: (a) fragment of ontology domain; (b) concept space graph for C1.19 - „Start-up“competence

according to the relationship between nodes path weights (η) and the threshold coefficient (λ) (Formula 1):

$$\eta(x_0, x_t) = W_s(x_t) \prod_{m=t}^{1} l(x_{m-1}, x_m) * W_p(x_{m-1}) \tag{1}$$

where nodes x_0 and x_t are two connected nodes.

If the purpose of a test is to check “Start-up” knowledge and the test level is D, then only questions using concepts DDI, DIP, DDP, ARP and PRO are selected. Testing the same competence for other levels (A, B, C) requires a coverage threshold of minim 0.04 (meaning that the examinee should know ARP, DDP, DIP, DDO, PRO, CPR, EEP concepts) (see Table 2).

Table 2. The coverage analysis for C1.19-“Start-up” competence using node path weight in the Project Management Automatic Assessment

Concept	η	η>=λ (λ=0.01)	η>=λ(λ=0.04)
ARP	0.15	TRUE	TRUE
DDP	0.125	TRUE	TRUE
DIP	0.1	TRUE	TRUE
DDI	0.06	TRUE	TRUE
PRO	0.045	TRUE	TRUE
CPR	0.03	TRUE	FALSE
EEP	0.03	TRUE	FALSE

4 Project Management Testing Model Based on Ontology Web Representation

OWL is a suitable language for testware, because it represents hierarchical concepts as in the SinPers course ontology[4]. Still, logical constraints can be indicated by adding custom XML attributes. In order to compose a proper test for project management evaluation, we calculate semantic coverage in concept space graphs, using a threshold indicator for difficulty. Therefore, OWL Lite, which is specialized in computation, is the most suitable language to express our needs. Following steps are done: ontology creation, namespaces declaration, creation of class hierarchy, properties definition and instances declaration.

The hierarchy of classes contains three types of classes: “pm:Concept”, “pm:Competence” and “pm: CompetencesGroup”. Concept class is a subclass of competence class, which is included in a competences group (technical, behavioral, contextual) [5]. Instance classes personalize the project management testing ontology. Concepts and competences get concrete values, like in the next example, which is valid, as a result of the “check ontology” facility of SemanticWorks [7].

The relations between DDI, PRO and CPR concepts are ilustrated in Fig.2.

In ontology representation, two types of properties are defined: data type and object type. The first ones are double values, respecting some cardinality constraints (a

```
<rdf:Description rdf:about="pm:C1.19">
  <rdf:type>
  <rdf:Description rdf:about="pm:Competence"/>
  </rdf:type>
</rdf:Description>
<rdf:Description rdf:about="pm:DIP">
  <rdf:type>
    <rdf:Description rdf:about="pm:Concept"/>
  </rdf:type>
</rdf:Description>
```

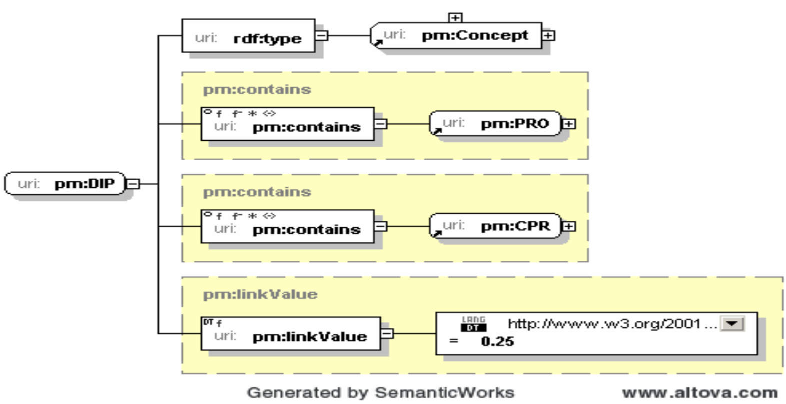

Fig. 2. Instantiations for Ontology Elements in Project Management Testware

node has only one self value or only one prerequisite value). The second ones have two attributes: domain and range. “DatatypeProperty:selfValue” is used to define the self weight of a concept node. “DatatypeProperty:prerequisiteValue” is used to define the prerequisite weight of a node. “DatatypeProperty:linkValue” is the property of the child nodes. The proposed metadata framework can be improved by defining transitivity or commutability relations.

5 Conclusions

The immediate benefit of the metadata language in extraction of relevant information from project management course material is reducing conception time and increasing configurability properties of computerized assessment. The testing model proves once again the importance of ontological approaches in processing digital content [8]. The model can be used to optimize the parameterized pool construction for computer adaptive tests [9]. Future experiments to check its validity will be made on the certification software of Romanian International Project Management Association (http://www.pm.org.ro/certexam/). This article is a result of the project „Doctoral Program and PhD Students in the education research and innovation triangle”. This project is co funded by European Social Fund through The Sectorial Operational Programme for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies.

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The EUCLIDES (Enhancing the Use of Cooperative Learning to Increase DEvelopment of Science Studies) Project – An On-Line Learning Portal Utilizing Problem-Based Learning

Fabrizio Boldini[1], Maria Rita Bracchini[1], Philippos Pouyioutas[2], Emilios Solomou[2], and Christina Ioannou[2]

[1] Centro Studi e Formazione Villa Montesca, Cittű di Castello CAP 06012, Italy
europrogetti@montesca.it
[2] University of Nicosia, 46 Makedonitissas Avenue Nicosia 1700, Cyprus
{pouyioutas.p,solomou.e,ioannou.ch}@unic.ac.cy

Abstract. This paper presents the EUCLIDES (**E**nhancing the **U**se of **C**ooperative **L**earning to **I**ncrease **DE**velopment of **S**cience studies) project (134246-LLP-1-2007-1-IT-1-COMENIUS-CMP), which aims at introducing and pilot testing an innovative teaching and training methodology, based on the Constructivist approach and on Problem-Based Learning (PBL), through the use of ICT instruments. This methodology has been developed for the study of science subjects and, is currently being used in some European schools of secondary education, involving teachers and students. A Moodle platform has been developed to enforce the application and use of the methodology. Through this platform, teachers can monitor the progress of the work of the students and intervene when necessary as facilitators to provide further co-ordination, pose questions and suggest problem-based approaches. The use of the platform secures that the teacher remains distant from the students allowing students to work by themselves and find solutions to the problems posed.

Keywords: Problem-Based Learning, Collaborative Learning, Web 2.0 tools.

1 Introduction

This paper presents a new pedagogical and teaching approach based on the Constructivist approach and on Problem-Based Learning (PBL), through the use of ICT instruments and state-of-the-art Information Communication Technologies (ICT) tools. This work is carried out as part of a European project namely EUCLIDES (**E**nhancing the **U**se of **C**ooperative **L**earning to **I**ncrease **DE**velopment of **S**cience studies) project (134246-LLP-1-2007-1-IT-1-COMENIUS-CMP), http://www.edu-projects.eu/euclides/index.asp. The project involves seven European countries, namely Italy, Cyprus, Spain, Romania, Greece, Bulgaria and Turkey. The aims of the project are more specifically to:

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- elaborate an innovative training methodology, inspired by the Constructivist approach, focusing on Problem-based Learning (PBL) and to make science studies more attractive
- promote in the institutions and in the educational systems of the involved countries a new pedagogical approach for the study of sciences, based on the Collaborative learning method and on the PBL through the use of ICT
- implement training activities for teachers of science subjects, in order to enable them to use the above mentioned methods
- use the proposed methodology, through an experimentation phase, in schools taking part in the project.

The project started with research on problem-based learning and its incorporation into the educational curriculum of secondary education in the partner countries. The findings of this research are available on the project's web site http://www.edu-projects.eu/euclides/index.asp. The project then continued with the definition of the didactic methodology that encompasses the use the of the Constructivist approach in the learning process. Based on this methodology, a portal has been created to allow students and teachers to embark in a collaborative learning process that entails research work and the use of ICT tools for creating learning material. The portal http://www.era-edu.com/euclides/ (login and password required) has been developed and is ready for the pilot implementation and experimentation with classes of schools of secondary education in the project participating countries.

In order to successfully achieve their aims, students will be introduced, during class and laboratory sessions, to the portal, as well as to various software needed to produce their work, such as multimedia authoring tools, Photoshop, social software and Web 2.0 tools. The on-line community (teachers and students) which will be created through the portal will share the submitted material. Furthermore, the portal will serve as a forum for exchange of information, ideas, as well as for casual communication between the students and the teachers of the schools.

This paper is structured as follows. In Section 2, we introduce the concept of problem-based learning. In Section 3, we explain the didactic methodology that has been adopted and underpins the development of the portal. In Section 4, we present the portal and explain its functionality. Finally, in Conclusions we discuss our current and future work related to the project.

2 Problem-Based Learning

Problem-Based Learning (PBL) is a total approach to education that challenges students to learn through an active engagement in real life problems. It was first used as a pedagogical approach in the 1960's at McMaster University Medical School (Ontario, Canada), in an attempt to restructure medical school education and enable students to apply their scientific knowledge to clinical problems. Today, PBL is used extensively in elementary, secondary and tertiary education institutions worldwide, and has also been adopted in various fields of professional training.

The key characteristics of PBL are that it involves team work and communication skills, a problem-solving capacity, critical, analytical, creative, as well as individual research [1]. Regardless of the discipline, PBL is a method that basically challenges students to think; it triggers their curiosity and their interest and engages them in a process of problem-solving that involves experiential learning, through the utilization of genuine experiences. Students then become *"engaged problem solvers"* [2]. They are able to identify the root of the problem and the conditions that are needed in order to find a good solution to it, thus becoming self-directed learners. Meanwhile, teachers/instructors become problem-solving colleagues or cognitive coaches, who build a learning environment that is receptive to open inquiry, and also provide enthusiasm for the students [2]. Throughout the process the tutor acts as a facilitator rather than a teacher. Instead of providing answers, the tutor encourages useful lines of questioning and problem solving techniques [3].

From the constructivist philosophical perspective, PBL is very important, as it is advocated that knowledge is something that is gradually constructed [4]. The constructivist view is in line with the idea that the instructor's role should be to provide guidance, rather than provide knowledge. Therefore, the continuous process of interaction and discussion that is embedded in PBL is consistent with constructivism. There are numerous ways in which PBL tutorials can be conducted. The most popular ones are the Maastricht process [1] and the Mills process [5].

One of the disadvantages that have been reported in relation to the PBL process is that it is a very different teaching process to the one that students have already received and, as a result, it can be stressful and disorientating [5]. The fact that students are no longer given the answers can require a change in their attitude and mind-set, and so it is better if it is introduced in a student's first year on a course [5].

The PBL approach, however, has numerous advantages. First of all, it promotes the development of life-long learning skills such as communication and interaction skills, research skills, as well as the ability to handle problems and work in groups. The fact that PBL challenges students to learn through active engagement in real life problems makes students retain the knowledge they gain for much longer. The process of experiential learning that students engage in, also allows them to reflect on their very own thinking process, and this makes them understand the problem better since they are more dynamically involved in the problem-solving procedure. All of these aforementioned effects of PBL contribute towards raising the motivation of students and gaining more interest in their subject matter.

Overall, the PBL process can be a very useful pedagogical approach, with many beneficial effects for the students. As already outlined, one of its additional benefits is that it is an interdisciplinary method of learning. As a result, the deviation from the more traditional system of learning and the departure from the traditional didactic mentalities that PBL provides in all fields, make individuals become better practitioners of their profession.

3 The EUCLIDES Didactic Methodology

The proposed didactic methodology consists of six stages. During the first stage, students are separated into groups and are given particular roles within their group. The rules of the game are also set, i.e. the role of the teacher and the students, how the group will work, what is required for the smooth functioning of the group, how to avoid or to overcome possible problems, the timetable and the tasks to be achieved, etc. Once the groups are established, the teacher proceeds to the next stage, the Scenario. This stage entails the presentation of a cartoon or video or newspaper article to students regarding a particular problem. This will trigger the discussion amongst students and teachers in order to identify possible problems which students will be asked to tackle. Each group will then select one such problem and will work on the problem definition, analysis of the problem, identification of their knowledge with regards to the problem, identification of the knowledge needed to solve the problem and hence and finally a plan of action to solve the problem. The Research Path is the next stage; this builds on the previous stage by specifying in more detail the research methodology to be followed in order to solve the problem. Students build the research hypothesis and identify in more detail the knowledge that they have regarding the problem and the knowledge needed, as well as the means through which they will achieve their aims. During the Product Development stage, students will develop the solution of the problem, which will be presented at the next stage, namely the Presentation of the Final Product. The use of ICT tools is crucial during these two stages since the student solutions will be presented and stored in the platform using state-of-the-art ICT tools. Finally, during the last stage namely Group Evaluation and Self-Evaluations, teachers and students will evaluate the work of each group. Furthermore, they will evaluate, through already developed questionnaires, the didactic methodology employed, the portal itself, as well as the benefits gained by using the methodology and the portal.

4 The EUCLIDES Portal

The EUCLIDES portal was developed to support and enforce the didactic methodology presented in the previous section. Thus, the main contribution of this project and the portal is that it provides a tool that enforces the use and monitoring of the methodology. It ensures that students are divided into groups and are allocated group roles. Furthermore, it makes sure that teachers are distant from students and act as facilitators, getting involved in the learning process only when needed. Finally, the portal requires students and teachers to participate in the forums, wikis, etc, thus promoting and cultivating communication skills and interaction, much needed for the PBL approach.

The portal is basically a collaborative on-line learning environment, where teachers store the teaching and learning material of their classes as well as the description of the problems that the students are asked to solve. Students use the portal to share their learning experience, store their work and communicate between them. It has been developed using Moodle and provides a visual presentation of the didactic methodology with appropriate headings, which when clicked on, redirect the user to the corresponding stage. The portal provides also links to some useful resources that students will have to use (Wikepedia, Slideroll, YouTube and Google).

5 Conclusions

This paper has presented the EUCLIDES project that entails a didactic methodology for teaching/learning in schools of secondary education. The didactic methodology focuses on a student-centered approach and collaborative learning, where students take control of their learning process and develop learning/teaching material as part of assignments/research work given by their teachers. Following a problem-based approach, students in groups, conduct their own research and produce web-based material using state-of-the-art ICT tools. Furthermore, the paper has presented the EUCLIDES portal. We claim that the portal provides an innovative approach to the application of the problem-based learning approach since it enforces the use and the monitoring of the aforementioned methodology which is based on problem-based learning.

All the partners of the project have already selected schools of secondary education in order to pilot test the platform/portal. The experimentation stage began in March 2009 and is expected to be completed by May 2009. Training of the school teachers took place in February. We expect to have an analysis of the feedback of both teachers and students by June 2009. Based on the feedback we will review the didactic methodology employed and accordingly adjust/amend the supporting platform/portal.

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Microblogging for Language Learning: Using Twitter to Train Communicative and Cultural Competence

Kerstin Borau[1], Carsten Ullrich[2], Jinjin Feng[1], and Ruimin Shen[2]

[1] Distance Education College of Shanghai Jiao Tong University,
3/F No. 500 Jiangsu Road, Shanghai 20050, China
[2] Shanghai Jiao Tong University, 1954 Hua Shan Road, 200030 Shanghai, China
kerstinborau@mail.online.sjtu.com,
{ullrich_c,jjfeng,rmshen}@sjtu.edu.cn

Abstract. Our work analyzes the usefulness of microblogging in second language learning using the example of the social network Twitter. Most learners of English do not require even more passive input in form of texts, lectures or videos, etc. This input is readily available in numerous forms on the Internet. What learners of English need is the chance to actively produce language and the chance to use English as tool of communication. This calls for instructional methods and tools promoting 'active' learning that present opportunities for students to express themselves and interact in the target language. In this paper we describe how we used Twitter with students of English at the Distant College of Shanghai Jiao Tong University. We analyze the students' messages and show how the usage of Twitter trained communicative and cultural competence.

Keywords: ESL, microblogging, language learning, communication.

1 Introduction

Most learners of English do not require even more passive input in form of texts, lectures or videos, etc. – they need a chance to actively produce language and the chance to use English as tool of communication. This calls for instructional methods and tools promoting 'active' learning that present opportunities for students to express themselves and interact in the target language. Such an opportunity is offered by social networks with English as the dominating language.

The following paper shows how the social network Twitter (http://twitter.com) was applied in an EFL (English as a Foreign Language) classroom at the Shanghai Jiao Tong Distance College (Online-SJTU) for seven weeks and two days in the summer term 2007. During the course, about 90 students made a total of almost 5580 updates – a rich dataset we analyzed for different indicators from a language learning perspective. To our knowledge, this is the first analysis of microblogging usage for EFL.

Twitter was selected because it provides the Chinese students the opportunity to practice the target language as well as their communicative and cultural competence. Most Chinese students are able to express their transactional intentions, but according to our experience, they have great difficulty to do this on a socio-linguistic acceptable

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level. Twitter has a huge advantage over usual discussion boards: Tweets consist of *short turns* including no more than one or two utterances. Discussion boards usually require the participants to create and follow up on a thread or to follow a thread and comment. This requires *long turns* which are significantly more demanding [2]. Since the creation of long turns is much more complicated and far more time consuming than the production of short turns found in tweets, it was decided that Twitter is more suitable for the language level and limited study time available to our students.

The paper is structured as follows. After introducing the setting of our Twitter case study in Section 2, we analyze the data in: the first part (Section 3) explores the use for language learning, namely the training of aspects of communicative competence as well as cultural competence. The second part (Section 4) analyses the student community engaged in Twitter as a blended learning community and points out the positive influence on motivation. Additional results are reported in Section 5. Section 6 discusses related work and provides a conclusion, including links to our datasets.

2 Description of the Case Study and the Datasets

2.1 Twitter and How It Was Used in the Course

Twitter is a social network in which the members of a community share their current activity by answering the question “What are you doing?”. This form of social interaction is called *microblogging*. Microblogging tools enable users to post short messages that are distributed within their community. Users can post messages from their mobile devices, a Web page, from Instant Messengers and desktop clients. The same channels are used for receiving messages.

Twitter seems to be a perfect tool to support learning English, especially in blended classrooms, for the following reasons. First, Twitter is easily accessibly from almost everywhere, so the students can practice at any time by sending and receiving messages either on the computer or the mobile phone. They can also decide how much time they spend reading and writing these messages. This is an essential feature for busy students. Second, Twitter is suitable for any level of English because in writing the messages, the students can chose a topic and grammatical structure fitting their level. Third, the use of Twitter as an online learning community can help to integrate students in the community who could not attend classroom.

In this work, the microblogging tool Twitter was used in an English course for native speakers of Chinese in the following way: the instructor created a new, personal Twitter account. As homework, the students of this class were prompted to create their own account and to become “friends” with the instructor’s account as well as with the accounts of the other students. Since each Twitter user receives the messages of his or her friends, each student who followed the instruction would receive the messages of his/her fellow students and of the instructor. The students were then told to post at least seven microblogging messages a week and to read the incoming messages of their fellow students.

2.2 Students and Study Context

The students at the Online-SJTU attend *blended classrooms,* that is, students can attend in person or virtually using their browser to watch a live stream of the lecture. Our blended classrooms are based on the Standard Natural Classroom model [20] providing face-to-face interaction with the instructor as well as online courses.

There are three main problems occurring in the English courses at the Online-SJTU: The limited time available for study, the different levels of English, and the size of the classes: the students at the Online-SJTU are adult learners which come from varying social and educational backgrounds. Consequently, there are also huge variations in their English levels. Some have been studying English continuously during the last 10 years while others have just started learning English in evening classes. Most of the students have a demanding full time job and hence do not have an hour of idle leisure time which they can fill with long-winded excises. Still, they spend time commuting or might have slack minutes in the office which they might as well spend learning and practicing their English skills.

The class sizes at the Online-SJTU vary from 80 to 120 students; thus not everybody has the chance to communicate with the instructor during class and practice his or her English skills.

2.3 The Datasets

The Updates

Twitter was introduced in June 2007 in the lecture "English Listening & Speaking" which aims at improving the students' communicative skills in English. In order to increase Twitter participation, participation in Twitter contributed to the students' final grade. During the period relevant for grading, the students' updates were counted each week and a score was assigned. The score did only depend on the amount of messages and did not take into account the linguistic correctness of the updates. To give students time to register at Twitter and to get familiar with its features, the grading period started two weeks after Twitter was introduced.

From the 110 students enrolled in the lecture, a total of 98 students registered at Twitter. Of the 98 registered students, about 10% (12 students) never used Twitter. One third (35 students) sent between 1 and 19 updates, again one third (39 students) sent 20 to 99 updates, and about 10% (12 students) sent more than 100 updates (10 students sent between 100 and 162 updates, and 2 students dominated the Twitter updates with 449 and 236 updates, respectively.

The dataset we analyzed covers a total of seven weeks and two days. During that time, students sent a total of 5574 updates, which corresponds to an average of 796 updates a week or 113 per day.

The Questionnaire

At the end of the lecture, students were asked to fill out a bilingual questionnaire (English/Chinese) about their usage of and opinion on Twitter. A total of 96 students completed the questionnaire. Of these, 82 students claimed to have used Twitter at least once. Since this paper investigates the effects of usage of Twitter, we excluded the 14 questionnaires of the students who never used Twitter from the analysis.

The questionnaire further showed that most participants (62 = 75%) of the students who completed the survey were female, 25% (=20) were male. Half of the participants were aged 20-25 (=42), 40% (=33) were aged 25-30, and 10% (=7) over 30.

3 Twitter and Language Learning: Training Communicative and Cultural Competence

3.1 Using Twitter in Training Communicative Competence

In our project, Twitter was viewed as a supplement to practice in authentic environment different aspects of the target language as it was taught in the classroom. One aspect of language learning which can be practiced in Twitter is *communicative competence* [13], a concept based on a view of language learning postulated in the communicative approach to language teaching, in which interaction is focused as a means of language learning and teaching.

Current views on language teaching emphasize communicative competence as the main goal of language learning (e.g. [19]). According to [3], communicative competence consists of four components: grammatical competence (words and rules); sociolinguistic competence (appropriateness), discourse competence (cohesion and coherence), and strategic competence (appropriate use of communication strategies).

In this paper, we will focus on two subcategories of communicative competence: sociolinguist and strategic competence. Further, we restricted the terms *sociolinguist* and *strategic competence* according to our purposes of our analysis.

Sociolinguistic Competence

We define *sociolinguistic competence* as the ability to use and respond to language appropriately, with regard to the setting, the topic, and the relationships among the community. We studied the students' updates with regard to their ability to express a specific attitude (courtesy, friendliness, annoyance). The updates show that most of the students have problems to choose the appropriate style and / or maintain one level of style. The following example illustrates the mixture of styles by using a more formal expression, "to pursue", and a rather colloquial expression, "wanna" (in the remainder of the article, all indented italic sentences are updates sent by the students):

"Richard suggested me chaning my life and pursuing the life I wanna."

The overall atmosphere on Twitter was polite and friendly; consequently the main style was in general colloquial. However, within the single updates students chose expressions of a rather formal style, such as "due to" in the first example and "I take responsibility" in the second, which is inappropriate for the purpose of communicating in an online community:

"Due to there will no classes on August, so I made a plan to visit Hongkong with my family."

"So I take the responsiblity of buying vegetable."

Other students sent updates in slang-like style spiked with swear words such as "damn" and "screw up", which is also inappropriate for the community:

"Damn exams,I hate it, A LOT! However, I don't wanna scew up on it."

“sleeping in the internet bar about 3 hours.Too damn uncomfortable.. take a bath about a.m 5:30...soon i will go to work...a day of unlucky”

Within the data, a large number of similar examples show that using a microblogging tool in a course focusing on communication provides numerous opportunities to practice sociolinguistic competence. The teacher should take up the these utterances and discuss them in class, to help the students understand their (in)appropriateness.

Strategic Competence

Strategic competence refers to the ability to handle communication breakdowns. In the following, we focus merely on how the students react if they don’t know the name of something or the right verb form to use. In these examples, the students didn’t know the correct name to refer to something, and thus used the Chinese word:

“’普洱茶’ is useful to lose weight. At least,it helps me a lot. Sorry, I don't know how to say it in English”

“桂林米粉 how to say in English?”

Judging from the update data, this strategy, which is also referred to as *appeal for assistance,* is utilized only in few cases. To further investigate strategic competence outside the Twitter updates, a series of questions inquired about usage of tools such as (online) dictionaries. When asked whether they use a dictionary for writing messages, a vast majority of 69.51% reported that they sometimes use a dictionary. 15.85% stated they never used one, and 14.63% stated that often used one. The figures for reading messages were similar, 67.07% sometimes, 19.51% never and 13.41% often used a dictionary. The utilization of dictionaries and the limitation to 140 characters in the updates partly explain the lack of using communication strategies in case of communication breakdowns; we therefore conclude that Twitter in itself is of no great help in practicing strategic competence.

3.2 Using Twitter in Training Cultural Competence

Cultural competence is a subcategory of sociolinguistics [7]. It consists of four categories: awareness of one's own cultural worldview, attitude towards cultural differences, knowledge of different cultural practices and worldviews, and cross-cultural skills. Cultural competence helps people from different parts of the world to effectively interact across cultures. In Twitter, the interaction with native speakers of English and the usage of English speaking Web-services helps to create a sense of cultural awareness and acquiring cultural competence in addition to English skills, as a student noted in the free answer section of our questionnaire:

“I also can learn some characteristic sentences by reading some native speaker’s messages.”

There is a need for training cultural competence with regard to Internet usage, as the following quote from the questionnaire’s free answers section supports:

“Twitter is a foreign chating network.It is hard for Chinese people to link it and update messages.”

According to the survey, the participants frequently use the Internet. 90% use it daily, 10% weekly. However, most of time, they visit Chinese Web sites. 37% of the students visit mostly Chinese Web sites, 57% more Chinese than English Web sites, 4% more English than Chinese Web sites and 2% mostly English Web Sites. Additionally, a large number of students stated in the questionnaire that they are in an all-Chinese environment and hardly ever communicate in English in their daily lives, which makes training cultural competence especially difficult.

In the questionnaire, almost half of the students stated that they communicated with native speaker on Twitter. However, it is difficult to confirm this data by analyzing the actual updates. Only few updates contain clear evidence that the updates were addressed to a person outside the class, for instance by stating the recipient's user name. Due to privacy restrictions, we were unable to use the follower list as an additional source of information. Still, if we believe the survey, students recognized Twitter as an opportunity to communicate with native speakers.

Of course cultural competence in its full scope cannot be acquired by simply joining a SN, but it can provide an insight into another culture and create an awareness of existing differences. Twitter allows the students to get in contact with people from different countries on a casual basis and thus provides cultural background to the target language. The awareness of different cultural backgrounds also includes an awareness of different communication strategies which become evident during interaction. Using Twitter, the students have the opportunity to communicate and interact more effectively with people across cultures; a skill which becomes more and more indispensable in the interconnected world of today.

4 Motivation through Community

4.1 Twitter as a Blended Learning Community

Blended Learning Communities are groups which utilize face-to-face meetings as well as online meetings. The social coherence and social interaction provided in online learning communities enable the exchange of information, and they further provide part of the motivation for the learners because the sense of belonging to a community of learners motivates the individual to conform to the group learning behaviors.

Evidence of a Sense of Community among the Participants in the Twitter Project
There is evidence that the participants in the Twitter-project indeed formed a community, first of all from the questionnaire. When asked whether Twitter improved the sense of community in the class, 40% completely agreed, about at third somewhat agreed, 23% were neutral, and 5% (= 4 students) disagreed.

Additionally, a number of linguistic markers for socializing can be found, such as greetings and group reflective observation, that is, any kind of comment on the group or its identity [15], and we also find humorous updates. A few examples follow.

A number of students visited Twitter in the morning before they started work, so we find different greetings which are variations of *good morning*:

"Good morning everyone."

" Morning!"

The students also visited Twitter before they went to sleep:

"So tired today, and going to bed now. Hope everybody ave a sweet dream tonight. See u tomorrow."

"Time to sleep now, have a good night and sweet dream to everyone!"
They also commented on the community in different updates. One update relates to the avatars used by the participants of the project:

"i just found something is funny, why everybody like pets in our class?for example:dog,cat and others."
Another student comments directly on the community:

"This "TWITTER" same as schoolyard~~~"
Humor as a marker for the forming of a community can also be observed in the updates. When the instructor updated that she was busy proofreading the exam papers for this course, a student jokingly offered his help:

"@kerstinlaoshi I volunteer to proofread the exam paper for you!"
Still, another interesting aspect of socializing is presented by the conversations in Twitter, which is described in the following paragraph.

Conversations in Twitter as Makers of Community
First of all, Twitter is not designed for conversations, but rather for updates ("I'm having lunch now"); still people engage in *conversations* [11, 18], which are markers of social coherence and community forming. In [15], Kellogg classified several features of conversations; in the following we will focus on what she designates as *Response* and *Elaboration*. According to Kellogg, *Response* includes responding directly to questions or points raised previously while *Elaboration* refers to elaborating on points raised earlier by oneself or others. The two latter features occur in conversation using the @ symbol. In [14] the authors pointed out that "since there is no direct way for people to comment or reply to their friend's posts, early adopters started using the @ symbol followed by a username for replies". However, Elaboration also occurs without the @ symbol and is only indicated by the closely related content of the updates referring to own or others' updates. The second type (no @ symbol) contains more general comments on topic, while the first type (with @ symbol) is used to make a specific statement or clarify a specific point.

The following illustrates a short but typical @-conversation about online shopping:

[15:21] babyyao: *@Nora_Tang:I would buy some cosmetics online these days.*
[15:55] Nora_Tang: *@babyyao I bought 4 books online just now. The most important thing is that the goods(shopping online) are cheaper.*

Below is an example of a short conversation without @ in which the updates are related through the topic "film":

[09:13] icyhe: *Transformer is very nice. i like it. Funny!*
[09:36] misterjustin: *i like the "bumble bee"best*

Of course these two features of conversations occur fused within in the data. For instance, the conversation on "Transformers" is longer and also contains responses with the @ symbol as well as elaborations; such as the following update, which actually triggered the updates relating to "Transformers" and movies in general:

"@kerstinlaoshi:so, how's the transformer? Was it as good as the ads?"

The questionnaire also investigated conversations. One third of the students stated that they often replied to updates of their classmates. More than half (56%) sometimes and only 14% never replied to updates. The updates confirm these numbers. In total, about 8% (=4 47) of the updates contained the "@" symbol.

Conversations implicitly provide motivation through social support by giving the individuals the sense of belonging to a group. In our data there are also conversations which provide social support explicitly in making it the topic of the conversation:

"maybe they are busy now. Don't worry! If you have some problems, you can contact with me ^0^."

5 Additional Results

In this section, we will briefly describe additional results from the questionnaire relevant for this paper, such as frequency and length of visits.

Three questions investigated the average frequency of Twitter visits and the time spent on the site. A majority of the students frequently interacted with Twitter. On average, one quarter (25.61%) stated they visited the site at least several times day. Again one quarter (25.61%) visited Twitter once a day. 39.02% went to the site less than once a day but still several times a week. 3.66% students visited it once a week, 4.88% less than once a week.

More than two third of the students spend little time to write a Twitter update. 31.71% spent less than 1 minute, 36.59% between 1 and 2 minutes. About one quarter (23.17%) spent 2 to 5 minutes. 7.32% invested 5-10 minutes, and only a single student (1.22%) spent more than 10 minutes. These figures substantiate the claim that Twitter serves as a quick and easy medium for informal communication.

A similar pattern was visible in the reading behavior. When asked how much time the students spent reading Twitter updates on an average visit, about 95% spent less than 15 minutes. More specifically, 26.83% spent less than 5 minutes, 45.12% from 5 to 10 minutes, and 23.17% between 10 to 15 minutes. Only 4.88% (4 students) spent between 15 to 30 minutes. No student spent more than 30 minutes reading updates. This data supports our expectation that Twitter is a tool that is frequently accessed for a short time span, with a short amount of time spent writing updates and a bit longer but still limited time spent reading the classmates' updates.

The effects of Twitter usage on English communication as perceived by the students were investigated by two questions. About 70% of students stated that they find it easier to communicate after using Twitter (30% completely agreed, 40% somewhat agreed). About one quarter (24%) had a neutral opinion and 4.88% (= 4 students) disagreed. No student completely disagreed. When asked whether they felt less shy when communicating in English after their Twitter usage, a similar but slightly less positive distribution arouse with 28% completely and 34% somewhat agreeing. 31% were neutral and 6% somewhat disagreed. Again, no student completely disagreed. All in all, these figures show a positive view on the effects of Twitter with respect to communication. Interestingly, the numbers of students disagreeing (4 and 5) was smaller than the students who sent no updates at all (12, as taken from the log data). This might be caused by the students seeing a "theoretical" value in using Twitter.

6 Related Work and Conclusion

Related work on microblogging covers either general suggestions on how to use Twitter in the classroom or analyses properties of the network and conversations without a focus on learning. In the former category, general hints and advice for academic usage have been published in several blogs (e.g., [1, 4, 17]), Websites (e.g., http://twitterforteachers.wetpaint.com) and publications [6, 8, 21]. [10] describe how they used a Romanian microblogging service to deliver an online course.

From an analytical viewpoint, the first published analysis of Twitter [14] reports on topological and geographical properties, and also describes the most frequent usage types (daily chatter, conversations, sharing information and reporting news). [16] analyzes a broader subset of Twitter users. In addition to information about its user base in general and its geographical distribution, they identify different users types based on the amount of followers, friends and update frequency. The specific kind of communication that takes place on Twitter is analyzed in [11, 18]. [18] shows that communication on Twitter goes beyond updating one's status messages. Most tweets address specific friends. This is confirmed by [11] who give a detailed analysis of the usage of Twitter as a conversation tool. A similar analysis is done in [12]; however the authors identify an inner, much smaller network of friends. Suggestions for analyzing microblogging are listed in [9]. Probably the only work that analyzes Twitter in the context of learning is [5]. They performed a frequency analysis over Twitter updates collected during an intensive one week summer school for PhD researchers. The students were instructed to use Twitter a back-channel for communication. In their data the most frequent keywords were directly related to the terms used in the summer school lectures, which indicates that the students were using Twitter as instructed.

The suitability of Twitter for language learning was often postulated, but to our knowledge until now never investigated in detail. Our work explores Twitter as a tool for active learning in the EFL classroom and provides the first detailed analysis of how Twitter was used to learn specific aspects of language. Our main finding is that it is suitable to train communicative and culture competence anytime anywhere without face-to-face interaction. In a broader scope, this work contributes to the research on using Web 2.0 services and tools for learning, so called e-learning 2.0. We show that the social, collaborative principles of Web 2.0 are reflected in its usage by learners, if used in the appropriate way. In our case, students clearly like using the service; one student even asked to continue to use Twitter after the project: *"Would you please do not close the twitter online? It offers us a free space to put ourself in English."*

To enable further research by interested parties, we made the dataset available as a free download on the Website "Many Eyes", a data visualization service by IBM. (http://manyeyes.alphaworks.ibm.com/manyeyes/users/ullrich).

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A Framework of Multimedia E-Learning Design for Engineering Training

Daniela Borissova and Ivan Mustakerov

Institute of Information Technologies – Bulgarian Academy of Sciences
Acad. G. Bonchev St., Block 2, 1113 – Sofia, Bulgaria
dborissova@iit.bas.bg, mustakerov@iit.bas.bg

Abstract. The paper presents a new framework approach for design and development of an interactive multimedia e-learning system for engineering training. The main goal of the paper is to encourage low cost developing of effective and customized e-learning systems for engineering training by using popular and inexpensive software tools. The proposed framework is a generalization of the authors' experience gained in developing of a pneumoautomatics e-training system. It can be used for developing of Web-based on-line or off-line e-learning systems for students or specialists customized training. The proposed framework is illustrated by some screen snapshots and descriptions of operational algorithms. The software realization of the pneumoautomatics example is done by means of HTML and JavaScript languages and was tested and used for students training.

Keywords: web-based e-learning, engineering training, multimedia, virtual simulation.

1 Introduction

The advance of information and communication technologies makes e-learning the focus of the modern education society. Using of the multimedia and visualization for the learning content adds new dimensions to the traditional educational methodology [1], [2], [3], [4], [5], [6]. The multimedia technologies provide tools to realize the simulation-based learning in a computer environment, in which the learners gradually move through the features of the learned object. There exists also a need for learning platform accessible and available 24 hours a day and reduces the requirement for trainer supervision [7]. In the field of engineering training sometimes conducting the learning activities and experiments on the real objects could be destructive or even dangerous. Computer-based simulative learning can be used in such situations.

There exist commercial e-learning systems for specific areas of engineering training. Most of them are quite expensive and complex and need essential efforts for learning how to exploit fully their features (see [8]) some of which are rarely needed.

The current paper describes a new framework approach for low cost developing of customized Web-based multimedia e-learning system for engineering training. The proposed framework is a generalization based on the authors' experience gained in

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developing of Web-based multimedia e-learning system for pneumoautomatics training [6]. The example of pneumoautomatics training is used to illustrate the design process by some screen snapshots, descriptions of algorithms and an excerpt of programming code.

The proposed approach could be an affordable alternative for students' education and engineering staff training. Along with relatively small costs it has the advantage to offer custom built Web-based e-learning systems that best satisfy the specific training necessities.

2 Multimedia Components and Web-Based Learning Systems Development

Using of multimedia components enlivens presentation of factual information and offers many advantages compared to the traditional educational methodology when used for e-learning [9]. It enhances text only presentations by adding interesting sounds and compelling visuals, improves over traditional audio-video presentations done with slides or overhead transparencies, gains and holds attention – combination of aural and visual presentation offers greater understanding and retention of information and is great entertaining educational tool. When used for engineering training the multimedia components provide important advantages [10], [11] – faster learning time, instructional consistency, flexible delivery, implicit learning and motivation, individual learning styles, testing of learning proficiency, cost, safety and documentation of the learning process.

There exist a collection of standards and specifications for Web-based e-learning (SCORM), which comes out of the Office of the United States Secretary of Defense [12], [13], [14]. The SCORM's recommendations are used in the current paper including evaluating existing content, analyzing potential audiences, designing sharable content objects, designing aggregations and designing content structure.

3 A Framework of Multimedia e-Learning Systems Structure for Engineering Training

Taking into consideration the SCORM recommendations and the specifics of the engineering learning domain, the development of an e-learning system should follow the structure of the learning process. For the engineering training some of the system development stages could be interpreted as following steps:

1) Evaluating existing content – analyzing and retrieving of the essential information about the engineering training from the existing sources – textbooks, company's prospects, etc.
2) Analyzing of the potential audiences – engineers, students and specialists.
3) Design of the sharable contents objects (SCOs) and their aggregations – for example, defining of the basic learning elements.
4) Design content structure – using multimedia tools for basic elements descriptions, system building principles and virtual system simulation.

The steps 1 – 2 are easy to implement following the traditional engineering learning process. Step 3 needs to define SCOs for particular engineering applications goals and also is based on the traditional engineering training. The most essential and time consuming is step 4. For the example of multimedia engineering training the most important activities of that step are a) introduction of the basic elements, b) combining of the basic elements into engineering system and c) virtual simulation of the engineering system operation.

A brief description and developing of the structure of these three learning content components in a framework of multimedia e-learning system design for pneumo-automatics engineering training are illustrated bellow.

3.1 Introduction of the Basic Engineering Components

The developing of an e-learning system for engineering training usually starts with the choice of a set of basic components for particular application area that should be learned as it is shown on Fig. 1 for the example of pneumoautomatics training.

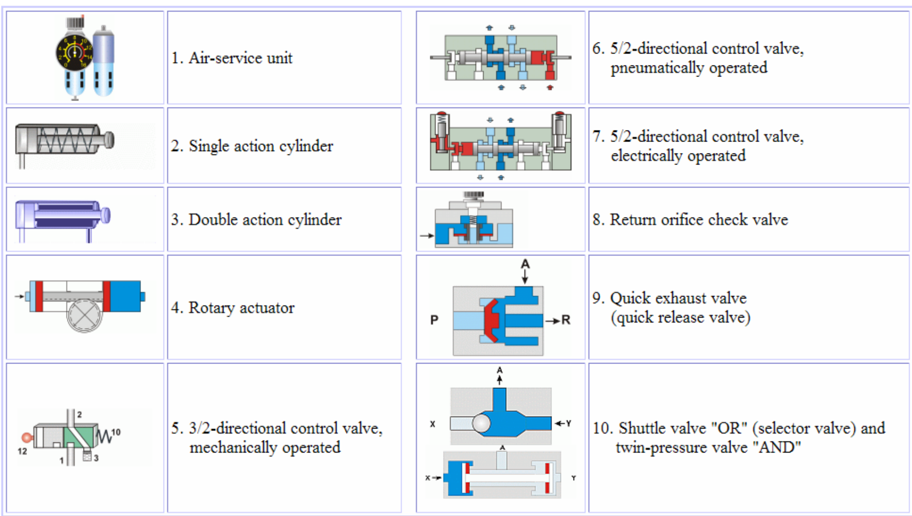

Fig. 1. Example of pneumoautomatics basic components

One of the most popular multimedia tools is computer animation. The engineering training can greatly benefit from visualizing of the engineering components operation by means of animation technique. As it is known the effect of animation is a result of rapid display of sequential still images. That means drawing of a sequence of images with certain image key areas changed accordingly to the desired movement [15]. For the chosen example a set of 8 intermediate positions are used to animate a particular pneumoautomatics component operation as shown on Fig. 2.

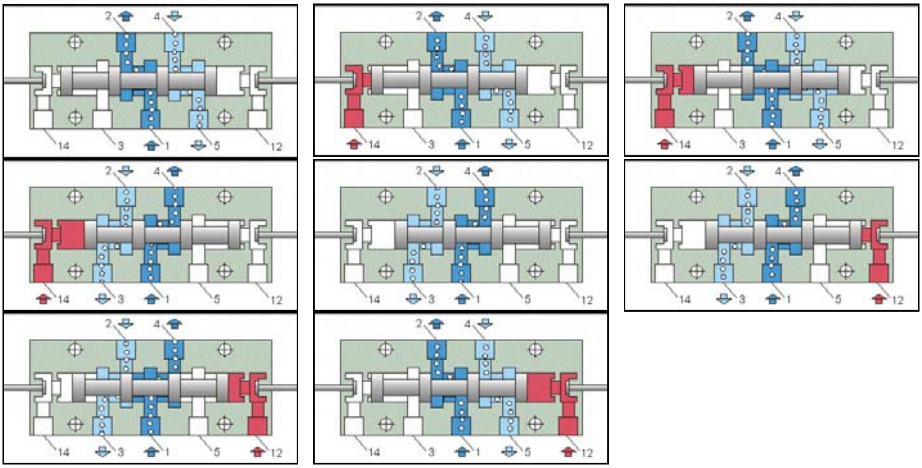

Fig. 2. Examples of components operation visualization with more intermediate stages

Using proper coloring the specifics of component operation could be expressed – air pressure, inlet and outlet air flows, etc. For example on Fig. 2, the light and dark blue colors are used to express different switching air lines. The red color is used to denote the control air flow. The red color brightness could be as information for the control air pressure – for example, dark red means high air pressure and light red means low air pressure. The component operation will be better visualized if each of the images from Fig. 2 is substituted with sequence of images to realize additional animation of the air flow movement by introducing some air bubbles. The images on Fig. 3 illustrate the substitution of the first of the drawings from Fig. 2 with six consequent frames where air bubbles positions are changed from frame to frame to get the animation effect of air flow motion.

It is clear that the needed animations effects depend on the specifics of the object.

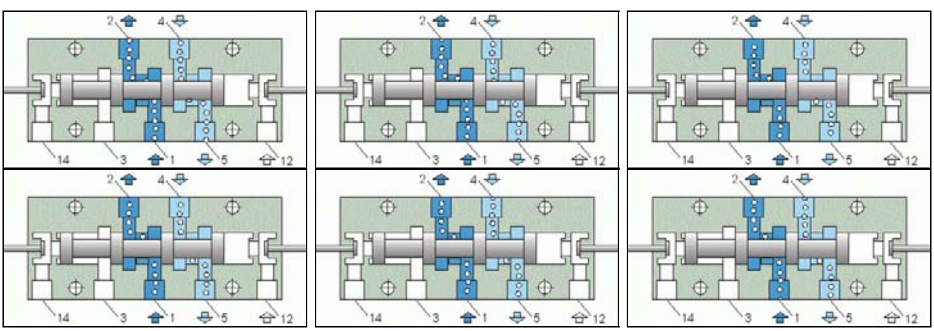

Fig. 3. Visualizing the air direction by bubbles movement

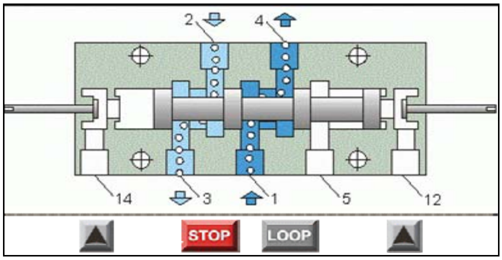

Fig. 4. Adding of "clickable" buttons

To improve understanding of the components operation an interaction could be implemented by adding "clickable" areas or "buttons" as shown on Fig. 4.

Finally, the developed component drawings could be schematic or more realistic (3D or pseudo-3D) taking into account that the use of graphic visualization in a simulation-based learning environment requires careful consideration with different abstract reasoning abilities of the learners [6], [7].

3.2 Combining of the Basic Elements into Engineering System

The learning skills for components using into an engineering system can be multiplied also by using of multimedia simulation tools. For the chosen example of pneumoautomatics system one of the possible approaches for that is shown on Fig. 5.

The different system elements could be activated by mouse "clicks" on different components "clickable" areas to change the corresponding system stage. For example, clicking in *E1, E2* and *E3* areas on Fig. 5a will switch the system through some intermediate stages the last of which is shown on Fig. 5b. Some details of algorithms for system operation simulation are described in section 4 bellow.

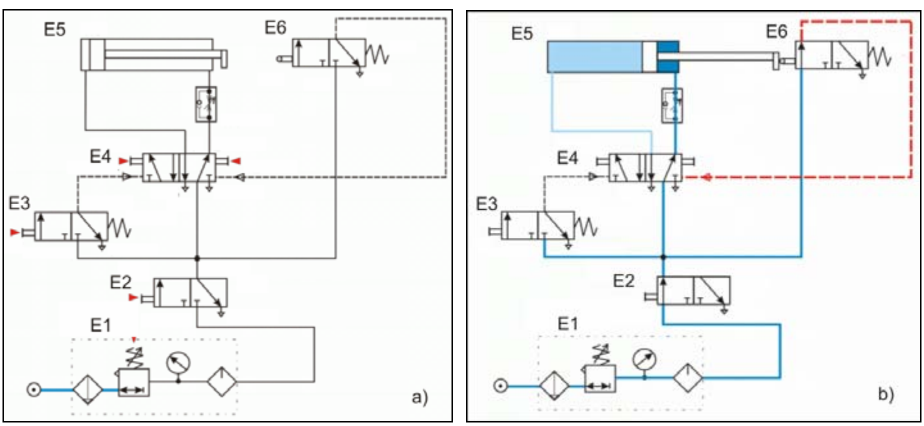

Fig. 5. Schematic pneumoautomatics system example

The engineering system operation could be learned by using sets of predefined system examples or by using of more sophisticated software constructions to build different system configurations.

3.3 Virtual Simulation of Engineering System Operation

The presentation of the system components in 3D or pseudo-3D will improve the visualizing of the system operation. For example, drawings on Fig. 5 could be transformed into more realistic pseudo-3D virtual presentation as shown on Fig. 6.

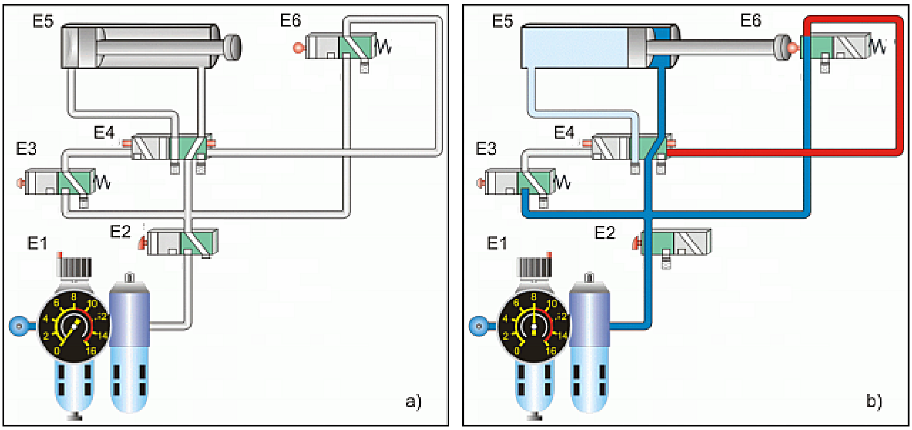

Fig. 6. Pseudo-3D presentation of virtual system example

The initial stage of the system is shown on Fig. 6a. The operational stage of the system represented on Fig. 6b is visualized by different colors of the air flow – light blue for atmospheric air pressure, different brightness of blue for different air pressure and red for control feedback. Sounds can be used to make the components actions more realistic. Some voice remarks and advices can also be triggered to explain some operational situations. Pop-up images and hypertext links can give additional information about the components. It is important to make the simulation as real in details as it is possible for achieving the learning goals. For example, if some components gauges are visualized they should represent the expected readings as it is shown on Fig. 6a – no pressure manometer reading and on Fig. 6b – eight bars pressure reading.

4 Software Realization of Virtual System Example for Engineering e-Training

The generalized algorithm for software realization of the described framework for design of an engineering e-learning system could be described as follows:

Step 1: Defining of ALL possible system states including fault states.
Step 2: Developing of drawings for ALL system states defined on Step 1.
Step 3: Defining the operational algorithm/s of the system.
Step 4: Software realization of operational algorithm/s from Step 3.

Step 5: Test of the software realization. If testing is successful goto Step 6, else goto Step 1 or Step 2 or Step 3 and Step 4 accordingly to the testing results.

Step 6: End.

The drawings for different system states (*Step 2*) correspond to the chosen type of visualization – schematic (Fig. 5), 3D or pseudo 3D – Fig. 6. All system components actions are interactive assessable by including "clickable" areas to simulate the components activating.

The second important stage in software realization of the engineering e-learning system is developing of the operational algorithm/s of the system with basic steps as:

Step 1: Visualize the initial system stage (Fig. 5a, 6a)

Step 2: Wait for user action – "click" on system activating areas.

Step 3: Change the system state by animation technique – rapid replacing of the system drawing correspondingly to the specific system operation. For example, if the system is in its initial stage (Fig. 5a, 6a) and user "clicks" consequently on components activating areas *E1*, *E2* and *E3* the system changes to the intermediate state shown on Fig. 5b or Fig. 6b which in its turn is unstable and system automatically goes to the stable state shown on Fig. 7a or Fig. 7b respectively and waits for user action, i.e. – goto step 2.

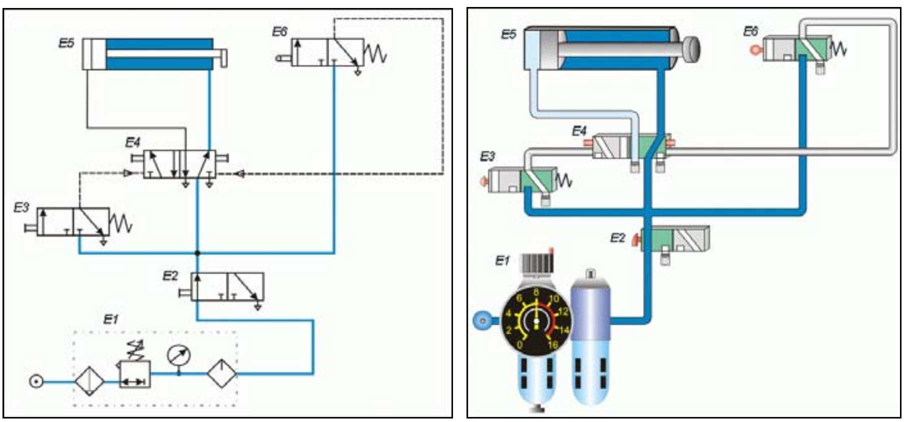

Fig. 7. Example of system operational stage

Web browser is accessible and free environment that can be used for realization of the engineering system virtual simulation. The popular programming languages for the browser environment as HTML and JavaScript could be used for software realization of the proposed framework. The practice shows that vast majority of students especially those from engineering profiles have enough Web programming skills and are capable of using HTML, JavaScript and presumably other programming languages and software tools as well. For the most of the engineering lecturers the computer and programming literacy is also an advisable requirement. Participation of the students and lecturers in the programming could keep programming costs sufficiently low. That approach will also give the possibility for easy modification and maintenance of the e-learning system.

If that is not possible, the programming costs will be commensurable with the costs for developing and maintenance of any similar types of software systems.

The excerpt of the JavaScript code used to simulate the system operation by implementation of animation effects in the pneumoautomatics example is shown bellow:

```
function Action0(simg,button) {
  var speed1;
b=button; //"clickable" buttons (areas E1,E2,E3,etc.)
  action=false;
  clearTimeout(t1);
  switch(simg) {
case 0:
  if(b==2)  {changeImage0(8);}
  else
  if(b==3){changeImage0(9);t1=setTimeout("gotoImg0(0)",30
0);}
  else if(b==4)   {changeImage0(10);}
  else if(b==5)   {changeImage0(0);  gotoStep0(0);}
  break;
case 1:
  if(b==2)  {changeImage0(2); gotoStep0(2);}
  elseif(b==3)
  {changeImage0(11);t1=setTimeout("gotoImg0(1)",300);}
  else if(b==4)   {changeImage0(12);}
  break;
case 3:
  if(b==2)  {changeImage0(12);}
  break;
case 4:
  if(b==2)  {cycleRight0(4,7);speed1=speed+speed+speed+5;
  t1=setTimeout("gotoImg0(1)",speed1);}
  break;
case 2:
case 7:
  if(b==2)  {changeImage0(1);  gotoStep0(1);}
  else if(b==3)   {cycleRight0(3,7);}
  else if(b==4)   {cycleRight0(4,7);}
  break;
case 6:
  if(b==2)  {changeImage0(1);  gotoStep0(1);}
  else if(b==3)   {cycleRight0(3,7);}
  else if(b==4)   {cycleRight0(4,7);}
  break;
case 8:
  if(b==2)  {changeImage0(0);  gotoStep0(0);}
  else if(b==3)
  {changeImage0(14);t1=setTimeout("gotoImg0(8)",300);}
  if(b==4)  {changeImage0(15); }
  break;
```

```
case 10:
  if(b==2)  {changeImage0(15); }
  elseif(b==3)
  {changeImage0(16);t1=setTimeout("gotoImg0(10)",300);}
  else if(b==5)   {changeImage0(0);  gotoStep0(0);}
  break;
case 12:
  if(b==2)  {cycleRight0(4,7); }
  else
  if(b==3){changeImage0(13);t1=setTimeout("gotoImg0(12)",
300);}
  else if(b==5)   {changeImage0(1);  gotoStep0(1);}
  break;
case 15:
  if(b==2)        {changeImage0(10); }
  elseif(b==3)
  {changeImage0(17);t1=setTimeout("gotoImg0(15)",300);}
  else if(b==5)  {changeImage0(8); }
  break;
  default:
  break;
      }
}
```

Taking into account the advantages of e-learning in network environments and especially in the Internet Web environment, any programming language that has appropriate tools for software applications in those environments can be used. The popular HTML, DHTML, XML in combination with scripting languages (JavaScript, PHP, Perl, etc.) could be as adequate for the goal as using of high-level languages – Java, C++, etc. The pneumoautomatics multimedia training courseware used as an example in the current paper was developed using HTML and JavaScript by team of three members – pneumoautomatics lecturer, a programmer and a drawing designer and was successfully tested for students training [16].

5 Conclusions

The motivation of the paper was to encourage low cost developing of multimedia e-learning systems for engineering training by using popular and inexpensive software tools. The paper presents a new framework approach for developing of customized courseware for engineering training. The described framework is a generalization of authors' experience gained in developing of Web-based multimedia e-learning system for pneumoautomatics training used to illustrate the design process. It was realized by means of HTML and JavaScript languages and was tested and used for students' education. The test results show that the developed Web-based multimedia e-learning system has been well received by students and lecturers. The simulative computer training increases the students' attention and learning content retention. Sometimes the interactive communication with the simulated pneumoautomatics system was accepted as a computer game provoking exploring (and learning) of all possible and impossible system states. By summarizing the test results it can be concluded that type of multimedia e-learning is effective and well tuned to the learning needs. The described framework can be used for developing of Web-based on-line or off-line engineering e-learning or e-training systems and could be an affordable alternative to the existing complex and expensive e-learning systems for engineering training.

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A Web 2.0 Personal Learning Environment for Classical Chinese Poetry

Yiwei Cao[1], Ralf Klamma[1], Yan Gao[1], Rynson W.H. Lau[2], and Matthias Jarke[1]

[1] Information Systems & Database Technology, RWTH Aachen University
Ahornstr. 55, 52056, Aachen Germany
{cao,klamma,gao,jarke}@dbis.rwth-aachen.de
[2] Department of Computer Science, City University of Hong Kong
Tat Chee Avenue, Kowloon Hong Kong
rynson@cs.cityu.edu.hk

Abstract. Classical Chinese Poetry (CCP) is a valuable but almost locked treasure chest of human wisdom and civilization since 2000 years. With the advent of the Web 2.0 a renaissance of CCP is possible even outside Chinese-speaking communities world-wide. With mobile technologies and educational games we can address new learning communities for CCP and open the chest again. In this paper, we introduce a Web 2.0 personal learning environment for CCP. We have developed a generic and interoperable data model for CCP we utilize not only for mobile learning scenarios but also for educational gaming with different levels of difficulty. Learners are empowered to learn Chinese poetry, language, history, and culture. This research work shows how modern information technologies assist users to diffuse knowledge across the borderlines of communities and societies.

Keywords: personal learning environment, classical Chinese poetry, Web 2.0, community of practice, educational gaming, mobile learning.

1 Introduction

As a crucial part of Chinese literature, classical Chinese poetry (CCP) is a valuable deposit of knowledge and civilization over 2000 years and reflects the versatile of history, society, economics, philosophy, and languages. Thus, it has great impacts on all Chinese-speaking regions world-wide and provides important learning and research resources. Reciting CCP has been ever part of Chinese language learning [16]. This conventional poetry learning method has been used at all Chinese classes on all Chinese school levels. Poetry is collective wisdom and knowledge of mankind over a long history. Aristotle ever claimed, “Poetry is finer and more philosophical than history; for poetry expresses the universal, and history only the particular” [6] which also gets to the point of Chinese poetry. Classical Chinese poetry is an important sub category of classical Chinese text and contributes greatly to Chinese literature. It is featured with certain ending syllable rhymes and consists of at least four lines of three characters, five characters or seven characters (cf. Figure 1) which we call a feature.

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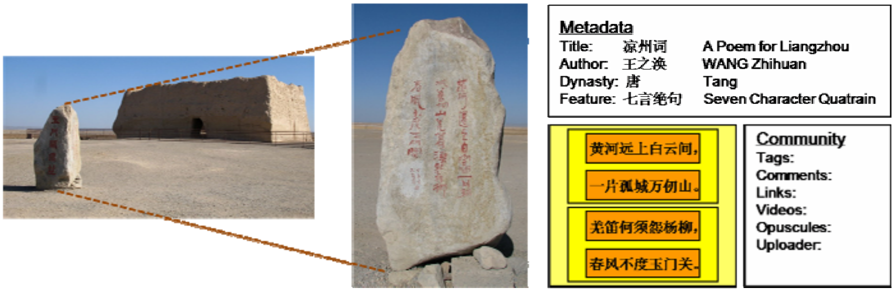

Fig. 1. The stone inscription of a seven-character poem written by one famous poet of Tang Dynasty. The stone is located at part of the Great Wall ruin along the Silk Road and the poem expresses the sentimental remembrance of the poet's hometown faraway. This poem with its metadata including title, author, dynasty and feature can be decomposed to e.g. 3 levels.

Poetry makes people think and does not have an instantaneous application field, as many essays do. Hence, Chinese poetry is not well spread to the rest of the world, compared to many master works of Confucius or Lao-Tse etc. belonging to classical Chinese text. In ancient China, classical Chinese poetry was the main learning content for students in private schools, the so-called Chinese Schools, which was the only location to have learning communities.

Several significant issues can be identified in current CCP. Firstly, the learner community has been widened and increased in versatile. Not only Chinese children learners but also Chinese adults and elderly people, foreigners, sinologists, etc. begin to show interest in learning CCP. Their goals among others are to use CCP as a vehicle for Chinese language training, to raise Chinese culture awareness and to keep Chinese traditions alive. Secondly, CCP has been losing its attractiveness in Chinese-speaking communities world-wide in comparison to a hundred years ago. The reasons are multifold again. For example, reciting CCP has been considered as a tedious learning task for children, compared to playing video games. Thirdly, CCP is not well spread outside Chinese-speaking regions despite its offerings of substantial Chinese knowledge over a long history. The learning barriers are high due to the difficulty of the Chinese language itself as well as missing access channels. Finally, modern information technologies have not been made good use of in CCP. In contrast, such ancient knowledge or culture is also raising new problems and conflicts by the rapid development of technologies. Technologies are shaping the interactions of communities in a way which may be conflicting with the traditional knowledge itself. Learning with new technologies may also deepen the understanding of and re-vitalize old knowledge for our times. Hence, it is challenging to discover the potentials of modern information technologies for preserving and developing traditional knowledge such as poetry. Research questions are addressed such as: How can information technologies find the balance between traditional knowledge even from ancient times and a great amount of digital media and information?

In recent years, information technologies have been applied to provide learners new means of accessing and learning CCP via Web sites, videos (e.g. youTube), television, radio, or some digital libraries. This shows that learners have great demands on free and world-wide access to a large amount of CCP learning content. Our aim is to lower barriers of access to traditional knowledge and to make poetry learning full of fun without much learning difficulties. A model of CCP is the basis for the design and realization of the personal learning environment (PLE) for learning CCP across learner communities.

The rest of the paper is organized as follows. State-of-the-art methodologies are discussed in Section 2 including a survey of existing CCP learning environments. Section 3 pertains to a comprehensive data model of CCP for learner communities and the conceptual design of our PLE. The technical aspects are presented in Section 4. Section 5 summarizes the paper with an outlook at open issues and future research.

2 Related Work

Related research areas include a set of social learning aspects. CCP makes important learning material at the Chinese lecture in classroom situations. The traditional CCP learning model is a community of practice [18]. This model has been demonstrated tremendously successful over centuries. So, it is the model we want to keep alive also in the Web 2.0 PLE. A *Community of Practice* (CoP) is a group of people who share a concern or a passion and do interact regularly to improve [18]. A CCP community has some *mutual engagement* such as reciting CCP or learning Chinese. They build up a *joint enterprise* using a *shared repertoire*. Hence, support of CCP learner communities can make good use of existing methods of developing successful CoP based PLE [12]. Community members are informally bound by common activities like participation and reification. Educational gaming can be well integrated to empower participation within CoP [17].

Today, learners create learning content with tools supporting their creativity. The technologies and tools supporting learners to produce content have made rapid proliferation possible. The idea of PLE was initially discussed in 2001 by Olivier and Liber [14, 8]. PLE help people control and arrange their own learning processes and provide support to set their own learning goals [5]. Thus, managing content and processes as well as communication with others in the process of learning are possible, too. There are only a few PLE which take advantage of the great amount of available multimedia materials on the Web 2.0 or even incorporate educational gaming approaches. Little interactive learning mechanisms or other new means are developed to stimulate learners' interest, to help learners learning poetry quickly, or to reach out to a wider range of learner communities. According to some pedagogues, most learning is *informal* [4]. Online learning communities and online knowledge repositories are the core of the current network-based informal learning environments. Media technologies allow a wide variety of activities and experiences which can support *language learning* [13]. How to manage and promote the informal learning in communities is still an open research question. Emerging Web 2.0 technologies may provide even better answers.

Stephen Downes [5] coined the term *e-Learning 2.0* which is derived from e-Learning concepts in combination with the Web 2.0 [15]. On the one hand, *social software* such as Flickr, YouTube, SlideShare [3] helps users create content in a community. On the other hand, *social software* assists users to adopt new ways of managing knowledge and improving efficiency, such as with RSS, tags, social bookmarking, etc. All these changes have shown that learners have more power controlling the learning environment. But little systematic research has been carried out to analyze the learning content and identify user needs like mobility and gaming. CCP data is not modeled at all. It is nearly impossible to achieve interoperability or exchangeability of CCP learning content across different platforms now. In practice, a Web 2.0 personal learning environment for CCP is a prerequisite for user-generated content (videos, Web sites, etc.), software beyond the level of a single device (mobile learning) [11, 15], and communities of practice.

Related to e-Learning and distance education, *m-Learning* as a new term focuses on learning across contexts and learning with mobile devices [11, 19]. A *mobile community* [9] is defined by Hillebrand et al. as a group of people who identify themselves with a common idea or interest and who have the desire to be spontaneous and flexible; participate in communication and get information wireless at any place and anytime. With the Web 2.0 technologies *mobile social software* [2] is emerging which can be designed as a kind of application running on wireless mobile devices with access databases on servers for learning communities.

For the technical aspects of Chinese language encoding and input, a variety of input method editors have been designed to allow the input of Chinese characters using standard keyboards [7]. Nowadays, UTF-8 is one of the most prevalent encoding of Web applications related to Chinese characters [1, 10].

3 Modeling and Conceptual Design of Classical Chinese Poetry Learner Communities

Our research tackles the aforementioned problems through systematical modeling, design and realization of a Web-based CCP PLE. A layer model is proposed to capture features of CCP learning on the macro, meso and micro scales. This generic model facilitates CCP exchange between different platforms.

Learner Communities

People, who learn CCP with different aims, have not the same educational background. Their expertise may range from novice knowledge, such as children and foreigners, to experts, such as students and sinologists. Learners are distributed all over the world. A centralized learning environment can not satisfy the requirements for CCP knowledge representation distribution in many media. We define here four levels of expertise in CCP. The first level describes the novices and the foreigners who know a little Chinese and want to improve it by learning CCP, or do not know Chinese at all, but have interest in learning Chinese. The second level contains the people who have recited some CCP but do not understand the content of them, such as younger children. The third level contains the students who have learned much about CCP and grasped some CCP spirits or artistic concepts behind the poetry, even the Chinese history and culture behind CCP. The forth level is the expert level. They research CCP as their profession or as their hobby, for example sinologists.

How to integrate the four groups in the CCP knowledge domain with CoP principle and how to spread the knowledge in the distributed community is a great challenge. Within a PLE it is needed to identify these learners with different knowledge degrees.

In CoP there is a clear distinction between master and apprentices. The apprentice learns from the master by observation mainly. Here, in a self-regulated learning situation learners on different levels must be able to recognize each other even in a virtual setting. It is possible for learners on different levels to approach more knowledgeable learners to get more knowledge according to their learning goals. In our PLE any learners can manage their own learning goals in such a way. In the Web 2.0 established practices are linking of Web resources or commenting on existing content. Other practices include rating of content and learners, visualization of content metadata such as tag clouds (folksonomies) and recommendations.

A Model for Classical Chinese Poetry (CCP)

The learning activities of users with different learning profiles are different. Usually learners learn CCP through repeating a word or repeating a sentence, from a single word to a single sentence, to a single paragraph, and to a whole poem.

The relational data model of our CCP PLE depicted in Figure 2 shows important entities involved in the Web 2.0 PLE. It is the core of the PLE design and realization. For the sake of brevity, we only explain some core entities (rectangles) and leave out the detailed description of attributes (ellipses) and relationships (diamonds). All entities are written in italics. *User* stands for all members in a CCP community including novices, foreigners, students and experts. *CCP* is the learning content repository. *Opuscule* is produced by the members of the CCP community. *Link* is submitted by the learners to CCP. *Comment* provides the key interaction in the CCP community, in the moment. *Feature* is the style of poetry. *Author* is the name of the poet. *Dynasty* stands the period of the poetry or the poet living in. This model can easily be extended with other Web 2.0 practices as needed.

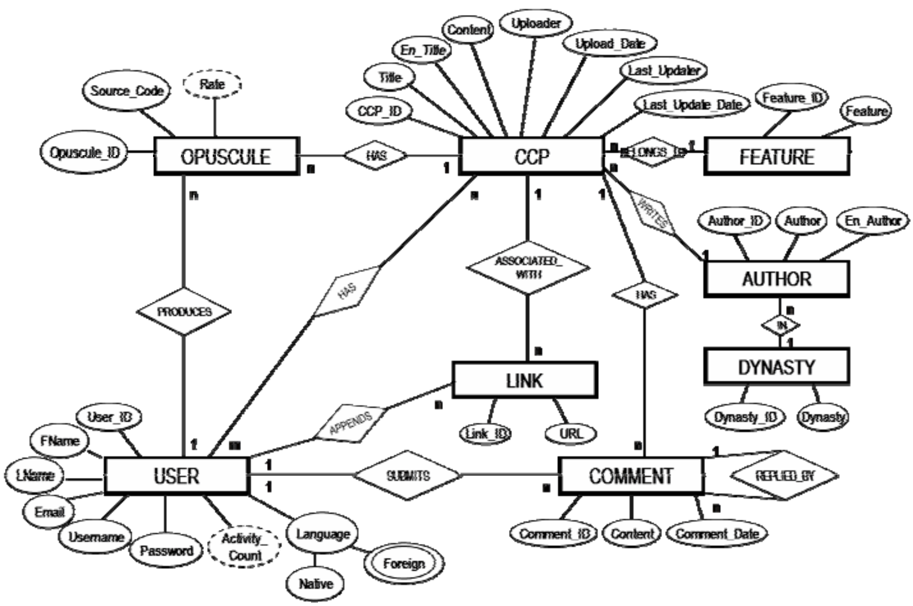

Fig. 2. A model for CCP PLE as Entity Relationship Diagram

According to the learning process, an abstract model for CCP is a three scale model consisting of micro, meso and macro scales. A poem can be modeled as an XML schema. Figure 3 is giving a graphical representation of an XML document tree.

- On the micro scale a poem is a collection of single Chinese characters. Micro content consists of character units.
- On the meso scale a poem is decomposed into short sentences ended by a unique punctuation. Meso content consists of sentence units.
- On the macro scale a poem is decomposed into paragraphs as a certain block (20% or 50%) of the poem or even the poem as a whole. Macro content consists of paragraph units.

The content scales fulfill the following rule:

Micro scale content ⊆ Meso scale content ⊆ Macro scale content

Metadata of classical Chinese poetry include poem title, author (poet), dynasty, feature ranging from 3-character to 7-character or tune name etc. Metadata can also be given in many languages besides Chinese.

Operations for Classical Chinese Poetry

According to the aforementioned poetry model, operations can be defined on three levels correspondingly: paragraph permutation (macro operations), sentence permutation (meso operations), and character permutation (micro operations). Performing these operations, users can learn CCP by playing games. A game setting can be specified based on the three main operations (cf. Figure 4), which have the following relationship among themselves.

Micro operations ⊆ Meso operations ⊆ Macro operations

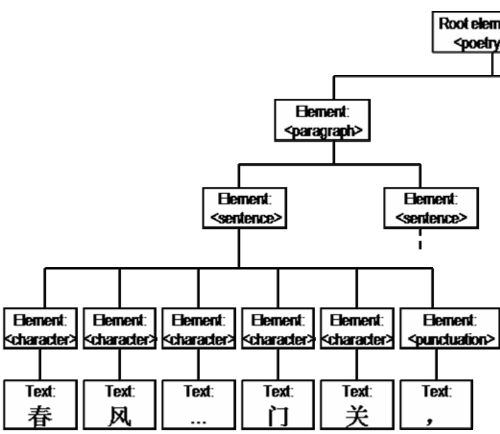

Fig. 3. CCP can be modeled in XML with tags like <poetry>, <paragraph>, <sentence>, and <character>

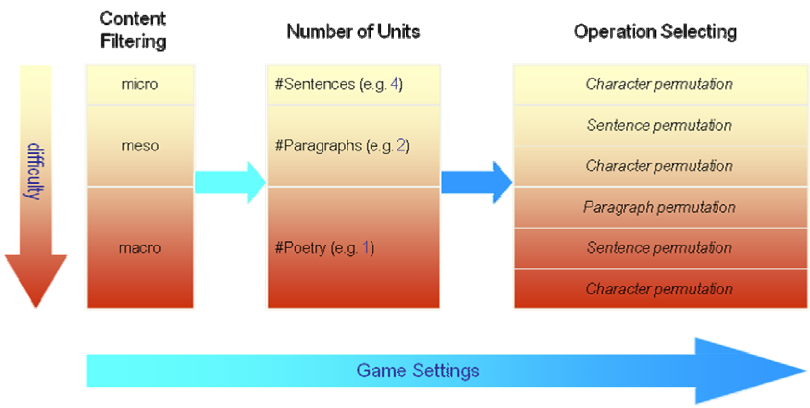

Fig. 4. Macro, meso, and micro operations in game settings

Learners can select a content level at first. On the macro scale, macro operations can be performed, while micro operations are performed on the micro scale correspondingly. With this flexible combination of content scales and operation scales, users can select learning content according to their learning profiles and preferences. Learning difficulty is raised from the micro-micro to the macro-micro combination.

4 Implementation of the Prototype CCP PLE

Based on the relational data model, the realization of the prototype CCP PLE focuses on the learner communities' requirements in order to help users learn CCP with mobility and with fun. CCP PLE is implemented using Java to make the program portable. Educational gaming is one of the most important features in CCP PLE. Hence, a set of Google Web Toolkit (GWT) tools is applied to support user interaction well.

GWT is an open source Java software development framework for web application development. It is featured with a Java-to-JavaScript-Compiler, so that the whole realization of both client and server side uses Java. It allows web developers to create AJAX applications in Java. GWT based applications are supported automatically in various Web browsers. *GWT Tooling* is a set of Eclipse plug-ins to simplify the development of GWT applications with Eclipse. GWT Tooling supports Eclipse Dynamic Web projects for traditional Java EE development as well as Java projects on the server side. *GWT Ext* is a powerful widget library that provides rich widgets like grid with sort, paging and filtering, trees with drag & drop support and so on. The *Ext JS* is a cross-browser JavaScript library with a host of rich widgets and components for building rich internet applications. *GWT-Ext library* helps tie together the functionality of the GWT and the widgets available in the Ext JS JavaScript library. Since GWT-Ext wraps Ext JS, the Ext JS library is also required as precondition for using GWT-Ext. *GWT-DnD* is a library providing easy-to-use drag and drop capabilities to GWT applications. Though GWT-Ext provides also some drag & drop support, but mainly for tree widget, while GWT-DnD makes the most widgets be able to be dragged.

The database on the backend is Oracle 10g database which supports Unicode very well. The GWT Remote Procedure Call (RPC) mechanism is employed to enable the client side to invoke codes on the server side.

In CCP PLE, users can upload poems with metadata and multimedia such as videos about the poem or various translation versions which are all stored in the database. Learner generated poems can be searched and selected for learning by gaming. The game difficulty can be chosen with the flexible combination of content scale and operation scales (cf. Figure 5) in order to match the users' learning profiles.

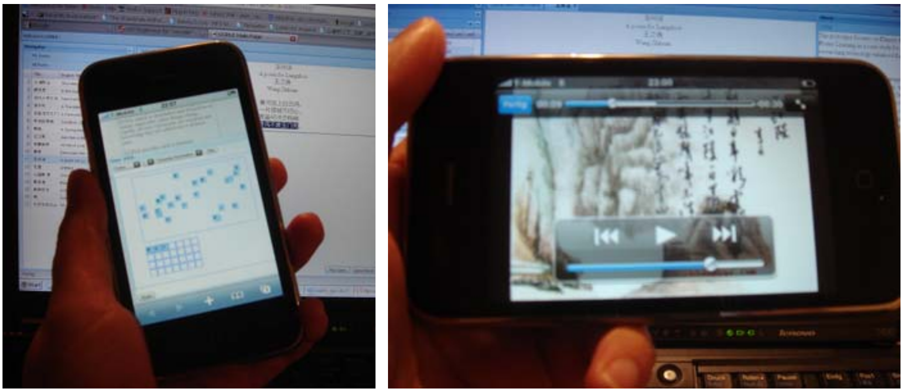

Fig. 5. The screenshots show CCP PLE in the Safari browser on the iPhone: the gaming setting with micro operations on macro scale content (left) and related videos on YouTube played (right)

After learners finish playing a game session, they can get feedback from the platform what learning achievement they have obtained. All achievement results are also traced and displayed in a grid panel. Learners' user names, game difficulty levels, and time for accomplishing games are listed to the learner community.

5 Conclusions and Future Work

In order to make more people access world-wide and share knowledge about CCP, a systematic classification for CCP learners and a comprehensive model including micro, meso and macro scale of CCP have been proposed. Based on Web 2.0 and CoP concepts, a platform-independent CCP PLE prototype was realized running on the Web or on mobile devices like the iPhone. Due to the generic data model, user generated CCP content and knowledge can be shared by users with the CCP PLE or in other environments which are interoperable based on the model. Game-based learning with flexible difficulty levels was applied to improve learning processes by competitive elements in the communities. The CCP PLE was only tested with less than 50 people with different educational background. We prepared a questionnaire for the learners, but after the evaluation period, only 17 questionnaires were returned. We did not an analysis on this far too small user basis. Perhaps we can report, that besides the language, lacking experience with Web 2.0 technologies is still a barrier, even among computer science students. Among those, 14 were native Chinese speakers and only 7 were also learning CCP before. Interestingly, 14 had never used a Chinese language learning platform before, and 12 even had never used an e-learning platform at all. 14 learners had learned about the Web 2.0 but only 8 had ever used Web 2.0 tools, but also for purposes different form learning. The functionality of the prototype is limited, so learners expect more new functions available in future. Some of them would like to produce video or flash for CCP themselves. Editing multimedia for CCP is a tedious process and not supported by any learning platform so far. Usually, a video consists of a meaningful animation of the content, a high-quality audio recording of the citation of the poem and some appropriate music track. There are no meaningful results about learning in communities, yet. Future research will cover community-based evaluation of learning success. But, for this evaluation we need access to more learning communities. We have already installed the CCP PLE on a public web server. So, the PLE is accessible from the Web. The URL is http://vermeer.informatik.rwth-aachen.de:9080/CCPLE/.

In our ongoing work, more Web 2.0 features such as tagging, rating, and recommendations will be implemented in CCP PLE. The internationalization of the platform will be increased via multi-language user interfaces. Learners can also share poetry or classical text in other languages and of other countries or regions in this environment. Deployment on various mobile platforms such as Nokia smart phones and Google G1 is still challenging. At the same time, a great amount of learner generated poetry content will lead to some uncertainty of learning content quality as well as poetry interpretation. This needs to be evaluated and tackled systematically, too. CCP PLE services will be integrated into the new EU large-scale integrating project ROLE (Responsive Open Learning Environments). The mission of ROLE is to support learner with simple means for building a custom personal learning environment without much prior knowledge. Construction support is provided through automatic suggestions of suitable tools and services respecting preferences, learning goals, knowledge, etc.

Acknowledgements

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Kinespell: Kinesthetic Learning Activity and Assessment in a Digital Game-Based Learning Environment

Ada Angeli Cariaga, Jay Andrae Salvador, Ma. Rowena Solamo, and Rommel Feria

Department of Computer Science, University of the Philippines, Diliman, Quezon City, Philippines, 1101
{adcariaga,jay.andrae.salvador}@gmail.com, {rcsolamo,rpferia}@dcs.upd.edu.ph

Abstract. Various approaches in learning are commonly classified into visual, auditory and kinesthetic (VAK) learning styles. One way of addressing the VAK learning styles is through game-based learning which motivates learners pursue knowledge holistically. The paper presents Kinespell, an unconventional method of learning through digital game-based learning. Kinespell is geared towards enhancing not only the learner's spelling abilities but also the motor skills through utilizing wireless controllers. It monitors player's performance through integrated assessment scheme. Results show that Kinespell may accommodate the VAK learning styles and is a promising alternative to established methods in learning and assessing students' performance in Spelling.

Keywords: VAK Learning Styles, Kinesthetic, Digital Game-based Learning (DGBL), Educational Games, Sun Small Programmable Object Technology (Sun SPOT), Assessment.

1 Introduction

Schools today are failing. According to NAEP (2006), 64% of students are below proficiency in reading and 78% of students are below proficiency in writing [1]. This is an alarming statistics that institutions must be alerted. Kids today are becoming different. They see play as a work and work as a play, prefer animation and graphics than text, view technology as part of their life and expects payoff for their efforts. [2]. According to Dunn and Dunn's model, there are three different learning styles that are widely used in the American school system, and it is called the Visual, Auditory and Kinesthetic (VAK) Learning Styles [3]. Classroom nowadays have lectures as the most used teaching technique but it may only cater students adept in visual and auditory styles of learning.

This is where Digital Game-based learning (DGBL) comes into play. It allows students to manipulate objects on their own while exploring the solution space [4]. Educational games capture a staggering degree of information that can be used to create detailed reports for assessment [4].

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DGBL can be developed to cater the VAK learning styles. Wireless devices are used to maximize kinesthetic potential of learner. Examples of wireless device include mobile phones and Sun Small Programmable Object Technology (SPOT) [5] that can be used as game controllers or sensors in the game.

There are lots of educational games developed and are now in the circulation but most of them lack the most important part in learning – assessment. Technology Applications in Education: A Learning View suggests an assessment cycle widely used in e-learning and can be applied to DGBL. There are four (4) main stages in the assessment cycle; Activity Selection Process, Presentation Process, Evidence Identification Process and the Evidence Accumulation Process [6].

2 Software Architecture

Kinespell includes two applications: the game application and the web application. The game interface serves as a bridge of interaction of the other components; the dictionary manager contains the player's own dictionary that can be shared on the web application; and the assessment engine gathers the player's performance record and generates assessment record that can be sent to the web application for repository. Figure 1 presents Kinespell's software architecture.

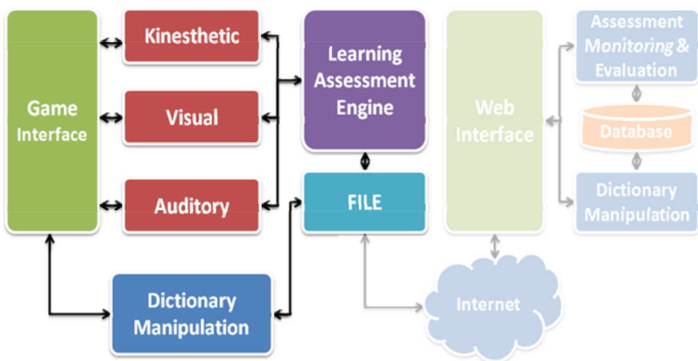

Fig. 1. Kinespell Software Architecture

3 Assessment

The system uses the assessment cycle presented in figure 3. The learner selects a category he wants to play and study. Then, it is displayed via the Presentation Process through the main game. Every time the player spelled a word, assessments are transferred to the Evidence Identification Process which identifies key observations such as hints used, live used, time elapsed, number of mistakes and number of correct answers and summarizes and updates the assessment record. Assessments done on each game are saved and can be viewed by the student or teacher.

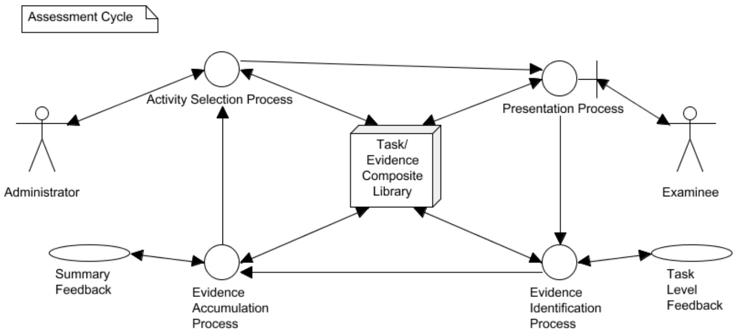

Fig. 2. Kinespell assessment is based on this assessment cycle[1]

4 Testing

Playtesting is done with the pool of target audience for the beta testing to test for basic functionalities, loopholes and interface acceptability after the alpha testing done by sample users. Playtesting was done in two (2) weeks and was conducted by seven (7) students from University of the Philippines Integrated System (UPIS) whom are chosen randomly disregarding gender and age.

The first week of testing was for familiarization of the testers with the system, game workflow and the Sun SPOT controllers. This allows the testers to explore the game space and feel comfortable with the game controllers.

The second week of testing was for evaluations, reactions and the final test of the testers. The final test is composed of a written and Kinespell test.

5 Results

Final Test results show that in using Kinespell, students were able to spell more words than on the written test. Also, Kinespell provides hints that aid the student in spelling the word and it consumes more time for them to finish the test. In terms of overall acceptability, Kinespell received high remarks on the children's evaluation. All of them want to use Kinespell in learning and studying Spelling. They all recommend using it in classes because they believe that it can make studying spelling easier. At the end of the two week play testing, the children were able to adapt to the Sun SPOTs and were even adept and comfortable in using them. The dictionary and assessment also received positive feedback.

6 Future Work

The authors need to collaborate with professionals in the education sector regarding specific measures for learning in games. The next set of testers should be formally

[1] O'Neil, H. F. Jr., Perez, R. S. (2003). Technology Applications in Education: A Learning View. Mahwah, N.J. : L. Erlbaum Associates, Publishers.

profiled by a psychometrician to determine which learning styles they are inclined so as to properly monitor their performance when playing KineSpell. The next phase of the project will be the implementation of the web application that functions as an assessment repository of the game. It will serve as a portal where the supervisor/parent can monitor players (student/child) online. Also, words entered in the dictionary are only prerecorded. The next step is the implementation of text-to-speech feature to automatically generate audio for every word.

7 Conclusion

Kinespell may accommodate the VAK learning styles and incorporating it provides a comprehensive technique in learning Spelling. The results also highlight the fact that the children believe that through the use of educational games, it will be easy for them to study Spelling. Since Kinespell with the use of Sun SPOT as the controllers received positive feedback, we plan to extend Kinespell to different Bluetooth enabled devices and other consoles like other mobile devices. Kinespell is a promising alternative to established methods in learning and assessing students' performance in Spelling.

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Influence of Perceived Information Overload on Learning in Computer-Mediated Communication

Chun-Ying Chen

Department of Electronic Commerce, Transworld Institute of Technology
1221 Zhennan Road, Douliu, Yunlin, Taiwan
cychen666@gmail.com

Abstract. Information overload (IO) is frequently reported as one of the main problems caused by computer-mediated communication (CMC), yet the literature is unclear about the impact of IO on student learning. This study therefore aimed to investigate the influence of online students' perceived IO on quality learning in CMC. Quality learning was defined as learning that is achievable by (a) reflective thinking through a deep level of information processing, and by (b) active learning through interaction with other people. The results suggest that students' perceived IO does not influence their deep processing as observed in their discussion messages, but might influence their participation and interaction with others in online discussions. Students' amount of invested mental effort put into study was observed as a major determinant of levels of information processing in this study.

Keywords: information overload, computer-mediated communication, computer conferencing, online discussions, amount of invested mental effort.

1 Theoretical Perspectives

The problem of information overload (IO) has been defined variously in the literature. The term "cognitive overload" is related to IO and the two terms were used interchangeably because both refer to the same theory that emphasizes constraints on human working memory. This study used the term "information overload" instead of "cognitive overload" because the former term was frequently reported as one of the main problems caused by computer-mediated communication (CMC). Generally, IO is related to excessive information, whereas cognitive overload is related to the impediment to knowledge construction. The human information processing model was used as a basis for clarifying the distinction between the two terms. IO and cognitive overload may occur in any of the cognitive processes (i.e., attention, storage, and retrieval) to interfere with student learning. IO usually occurs in the attention process when an individual experiences any interference from the environment resulting in information lost. Meanwhile, cognitive overload usually happens in the storage and retrieval processes. There is an overlap between the two in working memory and the overlap may help clarify the common explanation that both terms refer to the same theory emphasizing constraints on human working memory. In brief, cognitive overload is the load imposed on students during content learning, whereas IO is the "noise" preventing

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students from learning content. IO in educational CMC therefore in this study is defined as the point at which a learner's capacity of working memory is exceeded, and the excessive information and stimuli from the CMC learning environment interfere with content learning.

Because little is known about the phenomenon of IO in the educational CMC context, literature from the relevant areas of information technology and science, communication, psychology, and education was reviewed to identify elements likely to contribute to online students' IO. The review is summarized in Table 1 that shows the specific overload contributors structured according to four dimensions.

Table 1. Potential contributors of online students' perceived IO

Dimensions	Potential Contributors	References
Limited learner readiness	• A lack of technical skills for participating in CMC	[9]
	• Inadequate prior subject knowledge	[12]
	• Inadequate English reading/writing proficiency	[3]
Quantity of information	• Large volumes of information from Internet	[1]
	• Large volumes of information from the online discussion systems	[4], [7], [14]
	• Demands of course readings	[4], [14]
Quality of information	• Difficult learning materials	[11]
	• Text ambiguities	[13]
	• Redundant information	[8]
Medium interface	• The hypertext structure of online databases	[2]
	• The non-linear threading structure of the online discussion systems	[4], [7], [14]
	• Multiple conference spaces	[7]

CMC is acknowledged for its capabilities as constructivist learning tools to support conversation and collaboration [6]. Constructivist conceptions of learning assume that knowledge construction is achieved by the interaction that takes place within oneself through reflective thinking and by the interaction that occurs in communications and collaboration with other people [15]. Quality learning therefore in this study is defined as learning that is achievable (a) by reflective thinking through a deep level of information processing, and (b) by active learning through interaction with other people. Our main interest is to find out how students' quality learning, when encountered difficulties that created their perceptions of IO, is affected. Three questions guided this research:

1. Does students' perceived IO affect their levels of information processing (surface or deep processing) as observed in their discussion messages?
2. Does students' perceived IO affect their participation in online discussions?
3. Does students' perceived IO affect their interaction with others in online discussions?

2 Method

This study used a mixed-method design and three data sources were used in the study: a survey, semi-structured interviews, and observations of online discussions. At first, we employed a survey and interviews jointly to classify participants into different degree of IO groups for comparison. For data triangulation, the quantitative data obtained from the survey were used to support and verify the qualitative findings obtained in the interviews. Then, the quantitative content analysis of the observations of online discussions was examined to seek answers of all research questions. In examining the conferencing transcripts of the online discussions regarding interviewees' levels of information processing, participation, and their interaction patterns. Henri's [5] methods of relevant criteria were adapted and modified. Her methods of evaluating cognitive skills of surface or deep processing within students' messages and students' participation and interaction suited our research purpose.

3 Results, Discussion, and Conclusion

The results indicated that students' perceived IO might influence their participation and interaction with others in online discussions. But, the results suggest that IO does not influence students' deep processing, a finding that has not been reported in the literature. The amount of invested mental effort (AIME) that students put into study was observed as a major determinant of levels of information processing in this study. AIME is the main concept in Salomon's [10] model and his theory tends to explain some observations in the study. In this study, students' perceived demands of the medium and perceived self-efficacy (i.e., the perception of one's capability of obtaining information from the medium of CMC) were revealed in both of the interviews and the survey. First, it was observed that some High IO students were able to process information at a deep level, whereas some Low IO students processed information at a surface level. The High IO students' perceived demands of CMC tended to be high because they perceived the difficulties of learning in this environment. As for the perceived self-efficacy of High IO students who were able to process information at a deep level, they revealed their confidence for dealing with the difficulties contributing to their perceived IO. In contrast, it was observed that some Low IO students tended to post superficial messages. Low IO students' perceived demands of CMC tended to be low, meaning that they found it easy to operate and learn in the online environment. Consequently, those Low IO students with high perceived self-efficacy would not invest much mental effort into study. Students' less AIME on studying likely led them to more surface processing, although they did not experience IO.

Second, Salomon's theory also helps to explain the cases of some High IO students who were unable to process information at a deep level. Those students' survey identified their low perceived self-efficacy when they reported their lack of prior subject knowledge and computer competence. Their interviews revealed their great perplexity when they were frustrated with their online learning. Those students with low perceived self-efficacy will not put much effort into study when they perceived the demands of the medium to be high.

The findings of this study suggest that in order to promote quality interaction in online learning, the variables inherent in students such as AIME should be considered. Some future investigations are needed. First, future research could increase the sample size to confirm the observation regarding the relationship between students' quality interaction in CMC and the factor of students' AIME put into study. Second, future research could include an instrument measuring students' AIME for triangulation.

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A Federated Authorization Service for Bridging Learning Object Distribution Models*

Jean-Noël Colin[1], Tien-Dung Le[2], and David Massart[2]

[1] FUNDP, Rue Grandgagnage 21, B-5000 Namur, Belgium
jnc@info.fundp.ac.be
[2] European Schoolnet, Rue de Trèves 61, B-1040 Brussels, Belgium
{dung.le,david.massart}@eun.org

Abstract. In a large federation of commercial learning object repositories, customers might be confronted to different access control procedures put in place by different content providers to enforce their respective distribution models. This paper proposes a federated authorization service that provides a uniform access to learning objects protected by different authorization protocols. This service is based on a learning object broker that mediates different distribution models.

Keywords: Learning resource exchange, access control, mediation.

1 Introduction

As technology-enhanced learning is gaining in popularity, there is a concomitant growth in the quantity of digital content being produced to support learning and teaching activities. This content, also referred to as learning objects (LOs), is often integrated into collections that are stored in repositories and offered to educational actors (e.g., teachers, learners).

Educational content publishers aim at reaching the broadest audience with their content, while LO consumers want to have access to the largest content base. Creating federations of LO repositories that bring together publishers and consumers is a way to meet these two objectives. However, as different publishers usually support different distribution models, these federations frequently need to address important access control and intellectual property rights (IPR) issues.

Many solutions have been proposed to protect digital content. They generally rely on proprietary digital rights expression languages for defining content usage rules and on complex digital rights management solutions for enforcing these rules. In practice, putting in place such solutions requires the deployment of a

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complex infrastructure. This complexity is regarded as prohibitive by most of the publishers showing interest in distributing LOs in a federation.

This paper proposes a solution, based on a LO broker, to mediate the different authorization protocols in place within federations of LO repositories. It provides consumers with a uniform access to LOs while enforcing access controls derived from the different distribution models defined by publishers.

Section 2 provides a general overview of accessing and using LOs in the Learning Resource Exchange (LRE), a pan-European federation of LO repositories. Section 3 describes the challenges that arise in such federations in terms of access management. It proposes a generic and extensible protocol to support access negotiation. It also describes an original mediation mechanism that bridges the various business models used by federated repositories. Finally, Section 4 discusses the proposed model and offers some elements of comparison with related work.

2 Learning Object Discovery and Exchange

LOs range from simple atomic objects (e.g., an image) to very complex aggregates (e.g., a complete multi-media course). They are often described using metadata, i.e., machine-readable descriptions that help users finding LOs and assess their usefulness.

LO repositories are specialized software systems used to manage collections of LOs and their metadata. There exist federations of such repositories that provide a unified access to LOs stored in different repositories. With these federations, obtaining a LO is a three-step process [1]:

1. Discovery: Searching and evaluating metadata in order to select a LO that satisfies the needs of the user.
2. Negotiation: Gaining access to the selected LO. This step can be trivial when the LO is freely available and its location is provided in the LO metadata. In some cases, it can also involve complex authentication, authorization, and encryption schemes depending on the level of protection of the LO.
3. Exchange: Getting the selected LO at the location obtained during step 2.

The Learning Resource Exchange (LRE) is a new service that enables schools to find LOs from many different countries and publishers [2]. Over 128,000 LOs were made available when the LRE as a public service started to be offered to schools and teachers on December 1^{st}, 2008. Additional LOs from LRE associate partners are also being included in the LRE and the amount of LOs that schools can access is growing rapidly.

As depicted in Figure 1, the LRE federates LO repositories from various origins. LRE content is provided by ministries of education (MoE), commercial and non-profit content providers (Publishers), and cultural heritage organizations (Museums). It might also include user-generated content (Teachers).

The LRE is not limited to a single access point. Potentially, any application that utilizes LOs can connect to it including, for example, the LRE portal (http://lreforschools.eun.org), a national portal hosted by a Ministry of

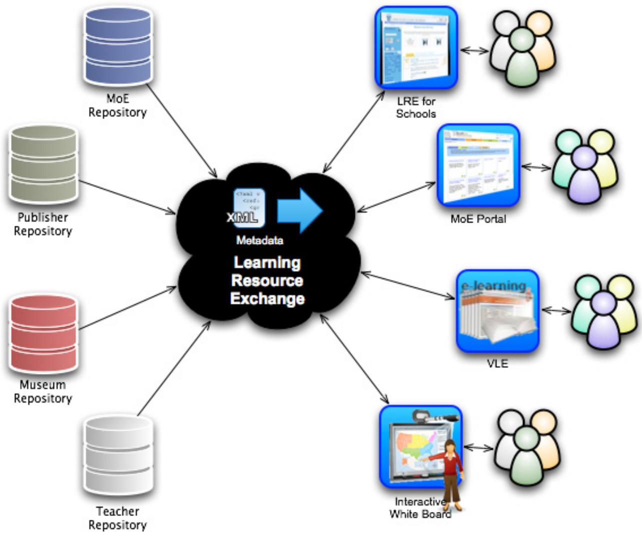

Fig. 1. An infrastructure for exchanging learning objects

Education (MoE Portal), a virtual learning environment (VLE) or a specialized device such as an interactive white board.

3 Federated Access to Learning Objects

In most situations, content distribution requires some form of protection against unwanted use of or access to the proposed resources. This protection may be required for different types of reasons, among which may be concerns regarding commercial, intellectual property rights (IPR) or privacy issues. Many solutions have been designed and developed to offer this type of service, that mostly rely on closed and proprietary technologies and implementations [3]. Their common objective is to protect digital content by defining and enforcing usage rules, hence the name of digital rights management (DRM).

Generally, DRM systems define three main roles: producer, publisher, and consumer.

- A producer produces content, or at least owns the rights to distribute it.
- A publisher manages the distribution system, including the DRM aspects of it. It collects work from the producers and offers access to them by consumers. In the LRE context, a publisher is a connected repository.
- A consumer accesses and consumes content; in the LRE context, a consumer is an end-user of a connected application that utilizes LOs, and by extension, such application is called a consumer site.

These systems provide ways of expressing rights (using some form of Digital Rights Expression Language — DREL — like XrML or ODRL [4], associating them with resources, and enforcing them; they may also include some tracking and accounting aspects. Generally, they make use of cryptographic functions and other digital protection schemes like both watermarking to protect content and track misuse, which requires a complex infrastructure to be properly managed. Additionally, they also require some functionalities for authentication, certification, revocation, electronic payment... The model proposed by the Open Mobile Alliance[1] or systems like Apple's iTunes^{TM}are typical illustrations of this approach.

The LRE takes a different perspective on managing access to resources and protecting them from unwanted use:

- No explicit rights expression is integrated at the LO level. In fact, most producers and publishers share a reduced set of distribution models that define the rules for accessing LOs. No complex licensing mechanism is required in this context, like spatial or temporal restrictions, limitations on the number of accesses. Once access has been granted, it remains so. Some expiration mechanism is available though. Although the first version of the LRE relyed on rights expressions embedded in resource metadata to determine applicable rights, this approach proved to be too complex to implement, and did not match the publishers requirements. Usage restrictions were based on very simple rules, and a DREL was not really needed; as a consequence, we prefer to use the term 'access control' rather than 'rights management'.
- No content protection mechanisms are included to avoid unauthorized use of LOs. The reason for this is that the benefits of these solutions to producers and publishers were not worth the effort, being often costly in terms of implementation and management. Producers and publishers both expect to distribute their LOs through rather controlled channels, but do not want to put additional controls or tracking mechanisms in place, at least for the time being.

These specific aspects of the LRE greatly simplify the design of a federated access control that includes the following components:

- Identification of the different distribution models that need to be supported at the LRE level.
- Definition of a generic protocol that is flexible enough to support the different models.
- Definition of a mediation mechanism to allow for a federated access control, independently of the models supported by the producer, the publisher, or any entity acting on their behalf.

The rest of this section discusses distribution models (3.1), then the proposed protocol (3.2) and mediation mechanism (3.3). Finally, the proposed approach is illustrated by a concrete example (3.4).

[1] http://www.openmobilealliance.org/

3.1 Distribution Models

As described above, LOs are made available following several distribution models that define the rules for content access. In the LRE, it is up to the publishers to decide which distribution models they support. Currently, we support three main models:

1. "Open educational content" is defined as LOs that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others. Open educational content can be freely accessible through a federation. However, some usage restrictions may be applied.
   Open Educational Content is identified by its use of open license types such as Creative Commons[2]. The distribution of open content may thus require first the acknowledgment of applicable licenses prior to actual resource access.
2. "License-based access" is the second popular distribution model in the LRE. A license grants the right to use a LO or a collection of LOs to an individual user or a group of end-users at a LRE consumer site. The license is, in most cases, materialized by a digital token. A license agreement between a consumer and a publisher must be obtained before the consumer sends an access request. This negotiation is outside the scope of the LRE and happens generally off-line.
3. "Credit-based access" allows end-users to "purchase" digital resources by spending LRE credits.

3.2 Federated Access Protocol

Because access is governed by globally defined distribution models, we rely on those models rather than on specific restrictions that would be specified at the resource level. This allows us to define a generic access protocol that can be used between consumers and publishers, or, in a federated context like the LRE, between consumers, publishers and a federated service acting as a trusted third-party.

The access protocol relies on a simple request/response exchange. A consumer (or a system acting on his/her behalf) sends a message to a publisher, requesting access to a particular resource; 'access' is understood here in the broadest sense that may be refined according to the actual distribution model. The publisher responds with a message granting or denying access. The request must carry all necessary information for the publisher to make an authorization decision.

[2] http://creativecommons.org/. In Europe, many Ministries of Education maintain collections of national web-based LOs for schools. Copyright law prohibits the use, exchange, and modification of any LO without the explicit consent of its copyright owner. Therefore, to authorize the usage of their LOs in the LRE, participant Ministries of Education agree to release them under Creative Commons licenses. These contributions of free LOs make it possible to reach the critical mass of quality content necessary to attract users.

Symmetrically, the publisher's response must provide enough information for the consumer to access the resource, independently of its format, access method, or protection scheme.

We define the concepts of 'access context' and 'access handle' as follows:

- Access context defines the context in which the request is taking place. It is a data structure that contains various information elements, depending on particular distribution model requirements. It is sent along with the access request and must contain the information that the publisher needs to decide whether or not to grant access to the LO. For instance, in a license-based distribution model, the *context* would contain the identifier of the LO, as well as some information showing that s/he owns (directly or indirectly) a license to access it (typically a license token);
- Access handle defines a way for the consumer to access the requested resource, in cases where access is granted by the publisher. It is a data structure whose content differs according to the actual distribution model. It must contain the information that the consumer needs to access the resource. For instance, in the situation where a LO is available at a specific URL, but where access is granted only after acknowledgment of some terms of use by the consumer, the *handle* contains the URL of the LO together with the terms of use or a pointer (URL) to them. In some other cases, the *handle* can be extended to include some cryptographic information, to allow for stronger content protection methods.

Currently, we define 3 classes of contexts, that all derive from an abstract context class (following the OO terminology). The abstract context defines the following attributes: A 'publisher identifier', a 'distribution model', a 'resource identifier', and an optional 'version number'. It also includes some tracking information. Based on this abstract class, we derive the following 3 concrete contexts:

1. 'Open educational content context' is used for open content, where no additional information needs to be provided to the publisher. It does not add information to the base context class.
2. 'License-based access context' is used for cases that require an appropriate license to grant access to LOs. It adds the 'license token' attribute to the base class. We further subdivide this context into 3 sub-contexts: An 'institution license context' that specifies 'institution', 'department', 'position' and 'role'; a 'personal license context' that specifies a 'subject' attribute; and a 'common cartridge context', to support Common Cartridge[3] packages that defines an additional element identifier.
3. 'Credit-based access context' is defined to support the credit-based distribution model. It extends the base class by defining the 'subject identifier', 'available credit' and 'credit currency' attributes.

Similarly, we define an abstract class 'handle', that contains the same information as the abstract class 'context' and an 'expiration date' that allows for

[3] http://www.imsglobal.org/commoncartridge.html

handle caching. Information from the abstract handle is used by the consumer to match the request and the response. Currently, we define the following concrete handle classes: 'URL handle' provides the location of the LO, 'license URL handle' provides the location of the LO together with the location of a license that must be displayed to the consumer and accepted. A Credit-based access handle contains actual cost of the accessed LO.

The LRE is based on a trust model where individual members do not have to know and trust each other. Rather, it relies on a common trusted service to validate the communications that take place between members and to vouch for their authenticity and integrity. Confidentiality of exchanges is not addressed at this stage, although it could be easily added by using communications over encrypted links. Consumers send access requests to the LO broker service that performs some validation, and forwards the requests to the appropriate LRE members. Similarly, publishers send responses to the same service that validates them before transferring them to the requesting members. An important point in this design is that, although very simple, the concepts of context and handle can be easily extended to accommodate new distribution models. Figure 2 illustrates these exchanges and the role of the LO broker as a trusted third-party.

Technically, the LO broker service is implemented as a set of web-services, deployed in a Java application server. As such, it is described by a WSDL file that defines its interface, and is made available at a service endpoint, identified by a URL. LRE members also implement services using the same approach, although no prescription is made about the development platform.

3.3 Mediating Access

In addition to being a trusted third-party in the federation, the LO broker also acts as a common service that bridges different distribution models, different authorization services, and technical implementations. Its aim is to *mediate* requests to digital resources, independently from actual distribution schemes. It offers a uniform interface to consumers, receives and validates incoming messages, and routes them to the appropriate service endpoint. Routing and actual destination endpoint are determined at runtime, depending on the context being sent.

Publishers connected to the LRE are free to select any of the distribution models described above that suit their business. Multiple models may be supported by a single publisher. Each model may require a specific authorization service at a publisher's site. The LO broker truly acts as a mediation engine in that it receives requests formatted according to the common LRE authorization protocol and is able to translate those requests into a specific authorization service implementation. We have specified a generic authorization service interface that publishers may implement, but our model also allows publishers to use their own authorization service, in which case the LO broker performs the necessary data and protocol translations.

When joining the LRE, publishers register themselves, and provide information about the distribution models that they support, together with the local service endpoint(s) of their authorization service(s). For this purpose, a LRE

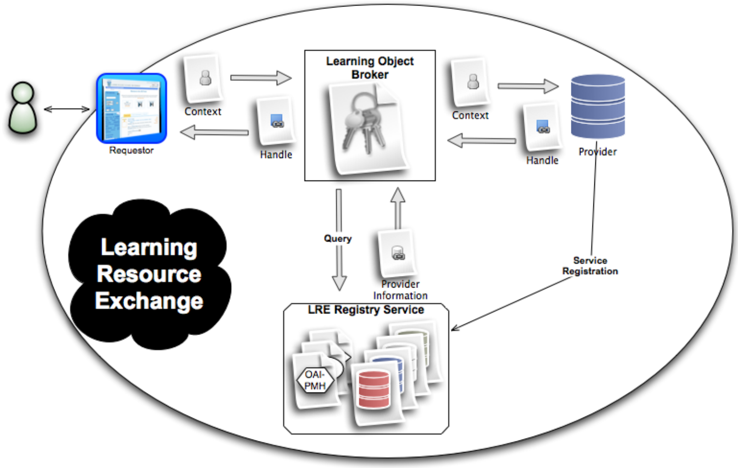

Fig. 2. Federated access control and access control mediation

repository registry keeps track of service registration and deregistration. It is the responsibility of the publishers to provision the repository registry with accurate data. Figure 2 shows the two LRE services, with the different messages.

First, the consumer requests access to a LO from a publisher by sending a request, expressed as a resource context, to the LO broker. The exact context is determined from the LO metadata obtained during discovery. Next, the LO broker checks the request validity, queries the LRE repository registry to retrieve the endpoint corresponding to the (publisher, distribution model) pair, and sends the request to that endpoint, after possible data and protocol translations. Finally, the LO broker receives the result, in a form that is dependent on the actual authorization protocol used, which is then translated into an appropriate Handle that is returned to the consumer. The LO broker is built around a plug-in architecture that allows one to add support for new models in a very flexible way.

Running the LO broker as a central service offers several advantages:

- As already described, it is a trusted component of the architecture, which simplifies the trust management in a highly dynamic environment like the LRE. On one hand, members only have one location to send their requests to and on the other hand, they do not have to accept any message that has not been validated by the central service.
- It hides the complexity of the local service implementation and provides a stable interface for the LRE members. Consumers do not have to bother about exact location for publishers services nor about differences in technical implementations.
- It allows for accounting and auditing. It records all transactions that take place and can then be used as a logging, auditing, or clearing mechanism. Non-repudiation of exchanges is implemented using digital signatures [5].

– Finally, it also provides secure exchanges, since LRE members may filter out messages not coming from the central service.

3.4 An Example: Common Cartridge Authorization

Common Cartridge (CC) is a set of open standard developed by the IMS Global Learning Consortium to enable interoperability between content and systems. It is designed to make a wider range of content available through educational tools like learning management systems (LMSs). The CC specifications define two actions for which authorization may be required: Importing a resource into a LMS and actually using the resource [6]. In the latter case, authorization may be required at the cartridge level or for inner components.

CC authorization makes use of authorization codes. A consumer requesting authorization needs to provide the identifier of the cartridge (or the individual resource) to be imported or used, as well as an authorization code. The CC authorization service replies with a yes/no answer, granting or denying the requested access.

Mediating the CC authorization service in the LRE requires the definition of the appropriate context and handle subclasses (CCContext and CCHandle respectively) to carry the information required by the authorization protocol.

The LO broker receives the standard access request from the consumer and translates the CCContext into an actual CC authorization service request. When getting the response from the CC authorization service, it extracts the information and repackages it into a CCHandle that is then sent to the consumer.

4 Discussion and Related Works

The proposed model goes beyond the work depicted in [7] and [8], by providing support for multiple distribution models and offering a mediation mechanism to bridge the different approaches and implementations present in the LRE. This makes it possible to clearly isolate consumers and publishers, by adding a trusted third party. It greatly simplifies the connection to the LRE by offering one single interface for consumers to request access to LOs, while, at the same time, it allows publishers to engage with different distribution models and support them either via the generic interface defined by the LRE or using another standard interface. This provides a very flexible and progressive way of joining the LRE.

Compared to other DRM interoperability initiatives [9,10], we are addressing a simplified context that does not require complex rights expression and content protection. In this context, we advocate that relying on generic distribution models is sufficient to match publishers' and producers' requirements in terms of rights protection, while still offering diverse ways of offering LOs to users.

Relying on a central service to mediate authorization protocols also adds to the flexibility of the model, by hiding protocol specific aspects and implementations.

The proposed solution allows for progressive and flexible adoption, and as such, makes the integration of consumers and publishers in the LRE as smooth as possible.

5 Conclusion

This paper proposes a federated model that allows for the mediation of access control mechanisms between consumers and publishers of LOs. It describes a generic protocol that supports distribution models commonly found in the LRE. This protocol is extensible enough to accommodate new models, if such need arises. The paper also presents a central service that bridges different distribution models by allowing consumers to use a single protocol for requesting access to LOs, independently of the actual implementation and location of the publishers' authorization services.

The approach has been discussed and validated with representative groups of both consumers and publishers to ensure the broadest adoption of the model in the LRE. Both LRE services are currently in their final development and validation with content publishers will start during summer 2009.

In the future, we will continue to work on the adoption of this common authorization service as well as on providing support for new distribution models.

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Far Away Yet Close: The Learning Strategy of a Transport Company

Pieter de Vries[1], Heide Lukosch[1], and Gerdje Pijper[2]

[1] Faculty of Technology, Policy and Management,
Delft University of Technology, Delft, The Netherlands
{pieter.devries,h.k.lukosch}@tudelft.nl
[2] ACHT Bedrijfsinnovatie B.V., The Netherlands
pijper@acht8.nl

Abstract. Rapid changes in the regulations and the organization of the transport sector make innovation an absolute necessity. The ability to cope with these changes depends largely on the learning capacity of the organization. The transport case described here is about the development of a sustainable learning strategy to handle the needs of the mobile workforce also in the long term. The solution is an integrated business portal built on the elements: information, communication, learning and performance improvement. The portal is online and functionalities are added to establish a stable and sustainable solution. Acceptance is growing, but management support remains crucial.

Keywords: learning strategy, mobile learning, Microtraining, transport.

1 Introduction: Towards a Sustainable Learning Solution

The transport world in general shows a mastery of logistics with a perfectly coordinated transport of goods, transport chains, freight handling, time windows, and planning arrangements. This practice is supported by a well organized workflow and dedicated transport software to ensure a minimum of errors and a maximum of efficiency. Rapid innovations in the industry and frequent changes in legal issues and regulations endanger the conservation and improvement of that mastery. Van der Wal International Transport, the case discussed here, decided to improve the learning capacity of the company to allow for adequate response. Most employees spend their days behind the steering wheel and the capacity for innovation largely depends on the ability of the organization to involve these mobile workers in the information, communication and learning circuit. This paper is about the newly developed learning strategy and some of the results of this ongoing project.

2 Development Strategy

The strategy framework used was the Corporate e-Learning Strategy model (De Vries, 2005; De Vries & Leege 2008). This model is marked by a holistic approach and three subsequent phases for the implementation of e-learning. The intake in the initial phase aims at developing a shared vision and consensus about the aims of the project both at

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the strategic, tactical and operational level. Phase two of the model is the pilot phase, in which solutions are tested in practice. Phase three covers the integration of these solutions in the organization. This paper covers the experiences in the first two phases of the project which is now in transition from phase two to three.

The analysis revealed that learning in a transport company is of a multi-dimensional nature which no longer can be served adequately with formal and traditional learning models. The daily reality comprises a broad spectrum of information exchange and learning, very much related to the need for performance improvement. The analysis conveyed the following three dimensions of requirements:

1. Information: an information system for news and other relevant resources; improved connections between the mobile colleagues to reduce isolation; involvement of all employees in the company's values; a driver's handbook as reference for daily tasks.
2. Learning: a concept for mobile learning to replace ad hoc and incidental learning practices and support the mostly informal learning processes; a concept that arouses interest and fits into the daily working schedule; the 'learning' activity must be monitored for supervision, support and planning.
3. Performance: KPI's (Key Performance Indicator) as a reference for performance requirements; job descriptions that adds transparency to the requirements; operational instructions as a structuring element for learning.

3 Theoretical Concepts That Match the Learning Requirements

The three dimensions of requirements clarified the goals for the new multidimensional learning strategy, which were mapped against educational concepts to be able to handle the multitude of issues and establish a firm theoretical basis.

A first concept was Social constructivism. Socio-constructivist principles seem to work well for informal, practical, ad-hoc-like and spontaneous learning (De Vries & Brall, 2008). Core of this concept is that each person is unique, has a learning past and learn best in a social context (Vygotsky 1978, Wertsch 1987). A second concept is Connectivisme which focuses on the changes taking place in society when it comes to knowledge and learning (Siemens, 2006). New information media (YouTube, Facebook, wikis) change the knowledge landscape in a rather quick way and the ability to connect to these different 'nodes' of knowledge, spread over a network of data, information and people and is called 'connected knowledge' (Siemens, 2006, p. 10). Truck drivers increasingly make use of mobile devices in their day to day working environment affecting their communication patterns, information acquisition, their learning and their social network. A third concept is that of the levels of experience (Jonassen, 1997). As people are unique learners, they also differ in their level of experience (see figure 1).

The next step was the educational design based on the three dimensions of requirements and the theoretical concepts. This design was called Microtraining, which is a development scheme for structuring self or group learning; develop learning materials, e-learning and other learning activities, based on workplace learning demands (De Vries & Brall, 2008). A Microtraining arrangement comprises a time span of 15-20 minutes for each learning occasion being face-to-face, online or in an e-learning situation (see figure 2).

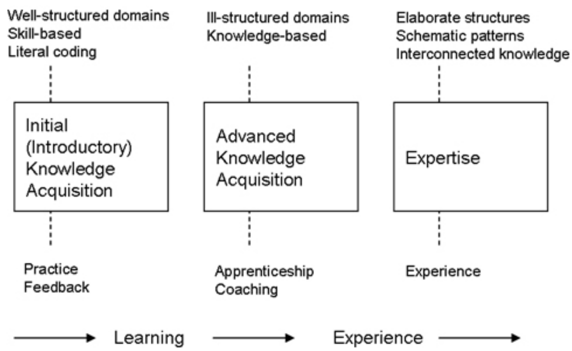

Fig. 1. Levels of experience (Jonassen, e.o. ,1997)

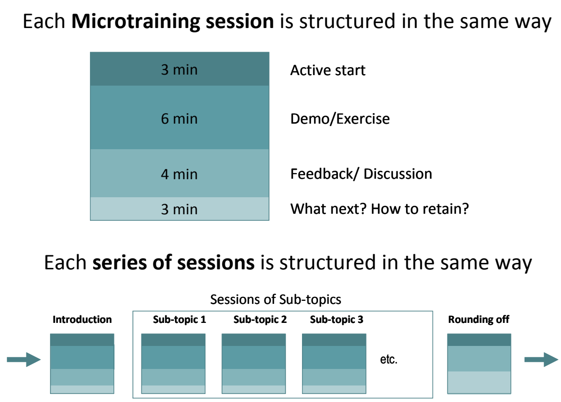

Fig. 2. The Microtraining workflow (Overschie et al., 2007)

4 Solutions and Actions

The solution contained a heterogeneous set of actions. Action one was the integration of the learning policy in the strategic business plans. Second was the development of a business portal for information exchange and access to learning resources. Third was the training of managers to use Microtraining in their daily activities and fourth was the development of a format for online Microtraining based courses. The technology used was an open source content management system which was integrated with the company's IT network for administrative purposes. The need to develop a sustainable solution self service for the long term is an ongoing concern.

4.1 Key Experiences

The project is moving from phase two to three as presented by the CeLS-model and data are being collected. Key experiences are the flawless integration of the learning policy in the strategic business plans. The business portal has become an interactive information exchange service used weekly by a majority of the employees. A first online course was delivered based on the Microtraining concept.

5 Conclusions

The new learning strategy has been rewarded by management and employees of the transport company as a strategic important innovation. Change though takes time especially when change of behavior is part of the innovation. The business portal is up and running and the increase of participation relates to the needed integration with working processes. The role of managers needs to be strengthened as it remains difficult for them to maintain an overview of the new methodologies and materials in relation to their tight agenda. This involvement should be carefully planned. The Microtraining method is perceived as clear and logical. Two items seem to be crucial. The holistic approach works well to derive a good overview and provide a better insight in the affairs of the company, the opportunities and barriers. The second item is involvement. The needs and wishes of management and employees are at the core of what this strategy is about. If it fits their needs, they will use it and start depending on it. The research data should allow us to reveal these notions more objectively.

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Bridging the Gap: Adaptive Games and Student-Centered VLEs

Ángel del Blanco, Javier Torrente, Pablo Moreno-Ger, and Baltasar Fernández-Manjón

Universidad Complutense de Madrid, Facultad de Informática
C/ Profesor José García Santesmases s/n. 28040 Madrid, Spain
{angel.dba,jtorrente,pablom,balta}@fdi.ucm.es

Abstract. The widely used e-learning technology is facing new challenges such as how to produce student-centered systems that can be adapted to the needs of each student. Those objectives should be met in a standard compliant way to simplify general adoption. In this context, educational videogames are proposed as an ideal medium to facilitate adaptation and tracking of the students' performance for assessment purposes. However, there are still barriers between the gaming and e-learning worlds preventing their mutual interaction. In this paper we propose a middleware to bridge this gap, integrating adaptive educational videogames in e-learning environments with a special focus on the ongoing standardization efforts.

Keywords: Educational videogames; Virtual Learning Environments; Adaptive Learning; Assessment; SCORM.

1 Introduction

Nowadays, the use of e-learning is increasing in industry and educational institutions. At the same time, e-learning systems have evolved from the original repositories of static content into richer Virtual Learning Environments (VLE), also known as Learning Management Systems (LMS) that follow different standards and specifications to assure the interoperability of the materials. The new student-centered features being adopted (such as VLE-driven adaptation of the learning experience or user tracking and assessment) demand further standardization efforts and raise new technical challenges.

Besides, there is an emergent trend in Technology-Enhanced Learning advocating for the use of educational videogames and game-like simulations [1, 2]. Educational videogames have key advantages such as their suitability to convey concepts [3] or to increase students' motivation [4]. Another key feature of educational games is that their high level of interactivity can provide fine-grained adaptation and performance-tracking mechanisms. This interactivity can open new possibilities in the e-learning field in terms of adaptive learning experiences, compared to those offered by more "traditional" hypermedia contents.

However, to bring the benefits of adaptive educational gaming to the e-learning field, we need to deal with the current diversity of VLE and with a lack of proper standardization support for the peculiarities of game-based learning.

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This article presents a general architecture to integrate games in VLE with special emphasis on supporting adaptation and assessment. This architecture is designed to provide an abstraction layer (i.e. middleware) that allows game designers to create adaptive educational games without committing to a specific educational standard, thus offering the possibility of reusing the same game in different VLEs and contexts.

This paper is organized as follows. First, in section 2, we analyze the current state of the e-learning field in terms of assessment, adaptation and standards; then, in section 3 we discuss how videogames can contribute to assessment and adaptation in e-learning and current challenges behind this approach. Section 4 describes the architecture we propose and finally, in section 5, we present some conclusions and outline future lines of work.

2 VLEs: Assessment, Adaptation and Standards

VLEs are rapidly evolving, giving the instructor more support and advanced tools to create complex online learning experiences. However, the increasing complexity of the content, including highly interactive pieces of content such as educational videogames, requires further support for the instructors. The new VLEs need to facilitate tasks such as tracking the progress and the skills acquired by the student within the games, as well as to adapt the learning experiences to the specific needs of each student.

Another important issue in e-learning is the interoperability of contents. At the present time, compliance to e-learning standards is a crucial factor when selecting a new VLE implantation within an organization.

E-learning specification and standardization initiatives are numerous, involving different organizations and consortiums such as the IEEE or IMS, and deal with the different aspects of the e-learning processes. This includes standardizing aspects such as supporting the creation of courses as aggregations of simple units of content (the Learning Objects Model [5]), the annotation of contents or the packaging of the courses. However, the ongoing standardization efforts are also covering more sophisticated aspects such as content sequencing or student profiling.

Even though the use of standards to package and distribute content is well established in current VLEs, these standards do not simplify the widespread adoption of student-centered approaches with adaptation and performance tracking. For that reason, some initiatives such as the IMS Learning Design specification [6] are aiming to provide a standardized representation of the full learning process, taking into account pedagogical values.

With a lower degree of expressivity but a much wider adoption, the SCORM framework (Shareable Content Object Reference Model) has been proposed by ADL (Advanced Distributed Learning). This framework, an initiative of the U.S. administration to improve e-learning [7], is probably the most extended solution nowadays. In addition, SCORM defines a communication model that allows the exchange of information between the content and the VLE in a standardized way.

However, currently two versions of SCORM coexist: SCORM1.2 and SCORM 2004 in most VLEs. Even though the newer version is more complete and adaptable, the full adoption of SCORM 2004 by mainstream VLEs (e.g. Moodle, Sakai or BlackBoard) is still an ongoing process. In addition, some environments such as those based on the IMS Learning Design specification [6] or supported by LAMS [8] are also valid alternatives for student-centered processes.

Therefore, the adoption of this type of advanced VLE demands dealing with a diversity of standards that may put the investment at risk. Given that developing interactive and adaptive content requires a significant budget, this can potentially become a major issue.

3 Game-Based Learning and e-Learning

As it has been widely discussed in the literature during the last years [9], the use of videogames can enhance the learning processes in many aspects. The most frequently cited benefits of game-based learning are the increase of the motivation of the students, the relation between videogames and constructivists theories [4] or their support for collaborative/competitive learning. However, the full potential of videogames for education is almost undiscovered and requires further research.

3.1 Videogames, Adaptation and Assessment

Nowadays, personalization is a common feature in videogames. Game developers and publishers include mechanisms in their videogames to adapt the game experience to suit the requirements of the widest possible range of users. The most obvious type of adaptation in videogames is the inclusion of different levels of difficulty, trying to adjust the challenge to different skill levels.

However, the potential is even bigger thanks to the high interactivity of games that can be used to implement much more fine-grained adaptation mechanisms (which can be carried out even transparently to the user). For example, the *MaxPayne*™ videogame incorporates Dynamic Difficulty Adjustment techniques [10] that alter the game execution depending on the actual performance of the user.

In addition, this fine-grained interactivity can also be monitored, allowing the collection of data gathered from user-game interaction that can be used to track the students' performance. This can bring new opportunities to the e-learning field to produce automatic assessment reports of the learning achievements of the player.

3.2 Current Challenges Integrating Game-Based Learning in VLE

As previously discussed we believe that educational games can be an ideal medium to deliver student-centered content in VLEs. However, new challenges must be faced to exploit the potential synergies between adaptive game based learning and e-learning.

One issue concerns the flexibility and maintainability of the content, a key issue in e-learning but which is rarely present in videogames. In order to become a more useful tool in student-centered VLEs, the games must behave more openly, allowing the instructor to know what happens during the game sessions and to modify the behavior of the game. This requires the definition of specific models that allow the instructor to interact with the game experience remotely. This can be done using the standards mentioned in the previous section, which presents two open issues.

On the one hand, a game developer who wants to integrate a game into a VLE must identify which standard/specification will be used in the VLE to store the data and how the games will exchange information with the VLE. Given the current situation, with diverse (and evolving) standards available, this does not guarantee the full interoperability of the contents, leaving the investment unprotected [11]. Besides, educational game developers must implement in each game the selected set of standards from scratch, which requires great efforts due to the inherent complexity of these standards. For a single videogame these issues may be acceptable, but if a large investment is planned, the problem becomes significant. This is especially relevant if we want to move towards educational experiences that contain diverse types of games that communicate with each other [2].

On the other hand, there are no tools that facilitate the addition of adaptive and tracking behavior to educational games. When developing an adaptive and assessable educational videogame, it is necessary to maintain a model of each student persistently, and developers must decide how to adapt the game experience according to that user model. If this behaviors are programmed ad-hoc in the game, the investment could become useless if instructors need to modify the adaptive and assessable behavior of the game (for instance, if the educational videogame is to be used in a new educational context). The problem of the student model persistence could be solved if instructors could directly set up the adaptation and assessment configuration of the game and connect the videogame with a LMS.

While the problem of connecting interactive content (such as games and interactive simulations) with LMS in standard-compliant ways has been partially addressed [12], there is still a need of research about how to use this connection automatically for adaptation and assessment purposes, and how to assure that the developed games will be resilient to future changes in the current standards.

Therefore, to facilitate the inclusion of educational games into the current student-centered VLE we need to achieve a greater independence between the implementation of the games and the standards used to connect them with the VLEs for adaptation and assessment.

4 The Architecture

In this section, we describe a general architecture that facilitates the integration of educational games in student-centered VLEs. The architecture was designed to alleviate the potential issues described in the previous section in terms of standards compatibility, adaptation and assessment.

4.1 Overview of the Architecture

The architecture provides a two layer middleware. The first layer, called communication layer (CL), abstracts the communication between the game and the VLE. This layer is dependant on the specific standards supported by the VLE (e.g. SCORM). The VLE-specific data is translated to abstract adaptation and evaluation concepts. The abstract adaptation data is transmitted to the game-adaptation layer (GAL) that is specific for each game or game engine. The GAL translates this abstract adaptation constructs into specific actions or transformations within the game.

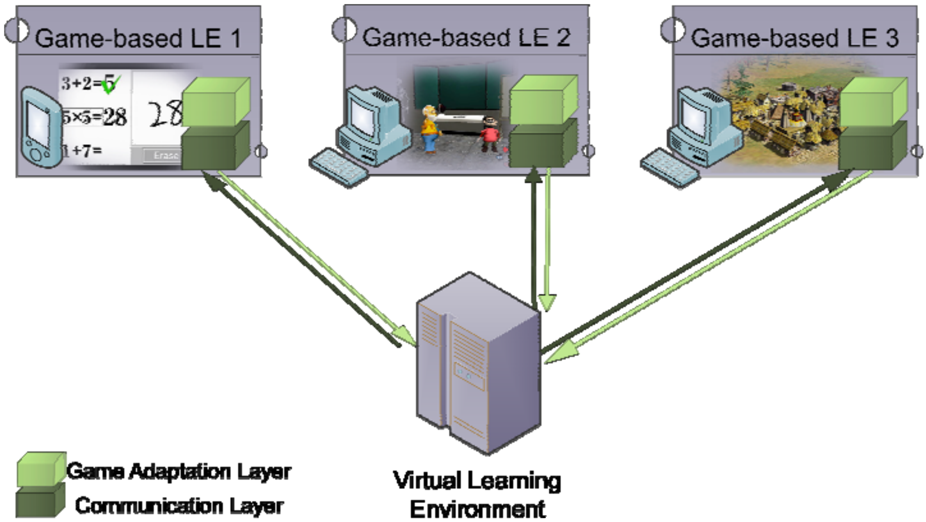

Fig. 1. General view of the architecture

In addition, the GAL tracks the activity of the student and uses such information to produce an evaluation of the student in abstract terms. The assessment abstract commands are given to the CL, which sends it through a standard-compliant channel to the VLE. Thus, the CL adds independency from the specific standard supported by the VLE both for adaptation and assessment communication.

The fact that the middle-ware employs abstract adaptation and assessment constructs means that both the game and the VLE can be completely independent and interoperable.

The role of the games in terms of assessment and adaptation is to provide valuable information about the performance of the student. This information is used by the middleware to drive a fine-grained online adaptation of the learning experience and to produce an assessment report that can be included in the VLE student profile. Those reports can be also used to update the student profile, therefore supporting a full adaptation cycle.

4.2 Using the Double Layer Middleware

The CL layer includes implementations for some common standards in student-centered environments (based on specifications such as IMS-LD, SCORM1.2 or SCORM2004). When the game is run, the CL consults a configuration file (communication settings profile) to select the standard used to establish the communication with the VLE.

For each standard, the CL includes two relevant elements: an implementation of the communication protocol between the VLE and the game-based content that the VLE supports or defines, and a profile specifying how to map the abstract adaptation and assessment data model that the GAL understands to the communication data model defined by the standard. In some cases, the standards already provide a

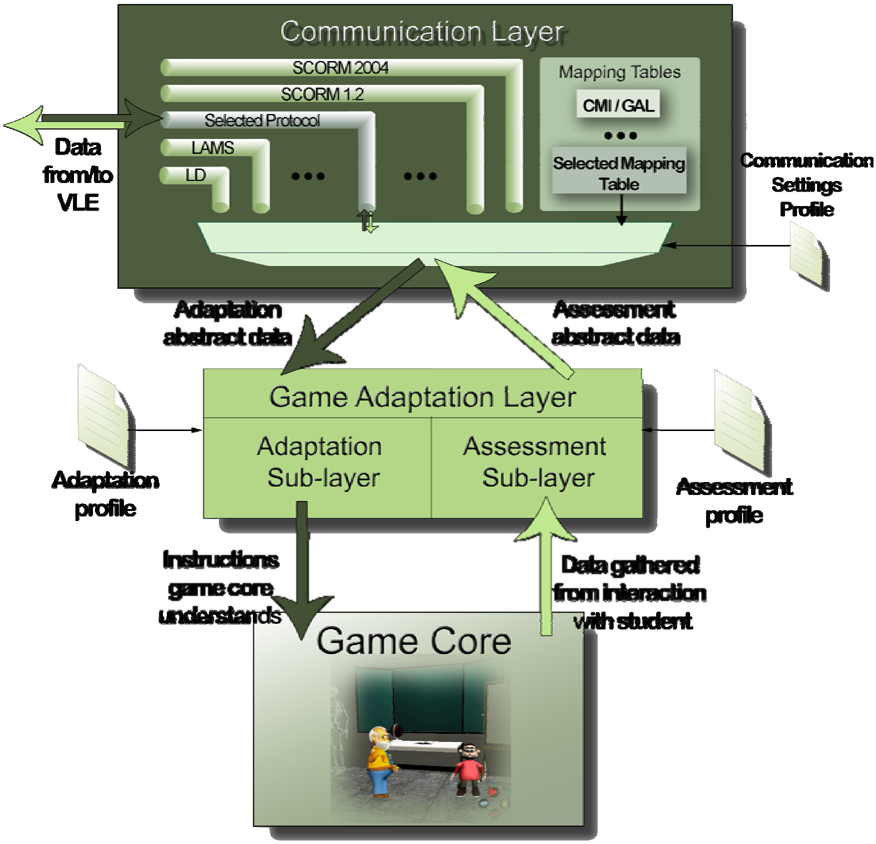

Fig. 2. Communication between the two layers (middleware) and the game core

pre-established data model (e.g. CMI data model for SCORM). However, when the selected standard does not define the communication data model (e.g. Learning Design) the Communication Settings Profile would include the mapping table that the CL must use in the communication to store and retrieve the required information. In these cases, the information contained in the profile will depend on the specific course (although it will be independent from the specific game).

The components of the CL are clearly isolated to allow flexible and systematic extensions and modifications of the layer, which guarantees interoperability and a longer life cycle for the architecture. New standards can be easily plugged in into the CL by carrying out two tasks: First, the communication protocol must be implemented following a specific API. In some cases this API will be provided by the standard (e.g. SCORM). In other cases, it will be dependant on the VLE. Secondly the mapping profile must be written, defining the translations between the abstract constructs and the VLE-dependant constructs.

In turn, the GAL focuses on translating the abstract constructs into game-specific commands. In a typical case, the GAL, via the adaptation sub layer (figure 2), polls the CL to get abstract adaptation commands (the CL gets the data from the LMS and translates it to the GAL language), and transforms those commands into game specific actions that modify the game experience. Then GAL will also listen to the interaction of the player in the game through an API that game developers must follow and will detect those situations that must trigger adaptation mechanisms. The specific actions that must be executed to adapt the game experience are defined by game authors through an adaptation profile (e.g. adjust the difficulty, give additional guidance, etc.).

The assessment sub-layer listens to the interaction between player and game as well. It uses also a profile (assessment profile), defined by the game author or the instructor, which determines the situations that must be assessed and how to track the activity of the student by defining assessment rules. When the game enters states matching any of the assessment rules (e.g. the student fails in completing a task) the assessment sub layer translates it into an abstract assessment construct.

Then the CL transmits the information to the VLE, encoded according to the data models of the specific target environment, so that the VLE can attach the results to the profile of the student. In this manner the student is re-profiled and in future executions the adaptation can be performed more accurately.

With this structure the underlying communication standards, as well as the specific details of each game are completely transparent. Authors only need to modify the middleware configuration file to change the standards and specifications used in the communication. Besides, the double layer middleware helps instructors and educational game developers to think about adaptation and assessment more naturally, without considering technical communication details.

4.3 Example of the Communication between VLE and Game

The architecture presented can be exemplified with the *"Paniel and the Chocolate-based Sauce Adventure"* game, which can be integrated into different student-centered VLEs. The game was originally developed to be integrated with a specific VLE which supports the IMS Learning Design specification [13]. The purpose of the game is to introduce chocolate-based cooking techniques from a practical perspective, and is divided in three stages of different levels of difficulty. The initial level (the simplest) teaches how make chocolate, the second level teach how make chocolate-based sauces, and the third level teaches how to combine them with dishes (the most challenging level).

For this game the GAL is set up with an adaptation profile that modifies the game depending on the prior knowledge of the student (figure 4b). When the game is executed, the GAL requests information from the VLE asking the overall grade of the student (figure 4a-step1). Then the CL, which has previously set up the communication channel with the VLE accordingly to the communication settings profile, codifies the request using the appropriate model, and sends it to the LMS. For instance, when deployed in a SCORM-compliant environment, the CL translates this abstract request into a check of the appropriate fields from SCORM's CMI data model (figure 4a-step2). The layer manages the request through the SCORM RTE and maps it to the GAL abstract data model (figure 4a-step4). The GAL then interprets the abstract response and uses the adaptation profile to decide to what level the student should go, skipping the first levels if appropriate. In this example, the adaptation profile determines that if the student overall grade is greater than 50% and less than 75% the first level is skipped. If the overall grade is greater than 75% the second level is

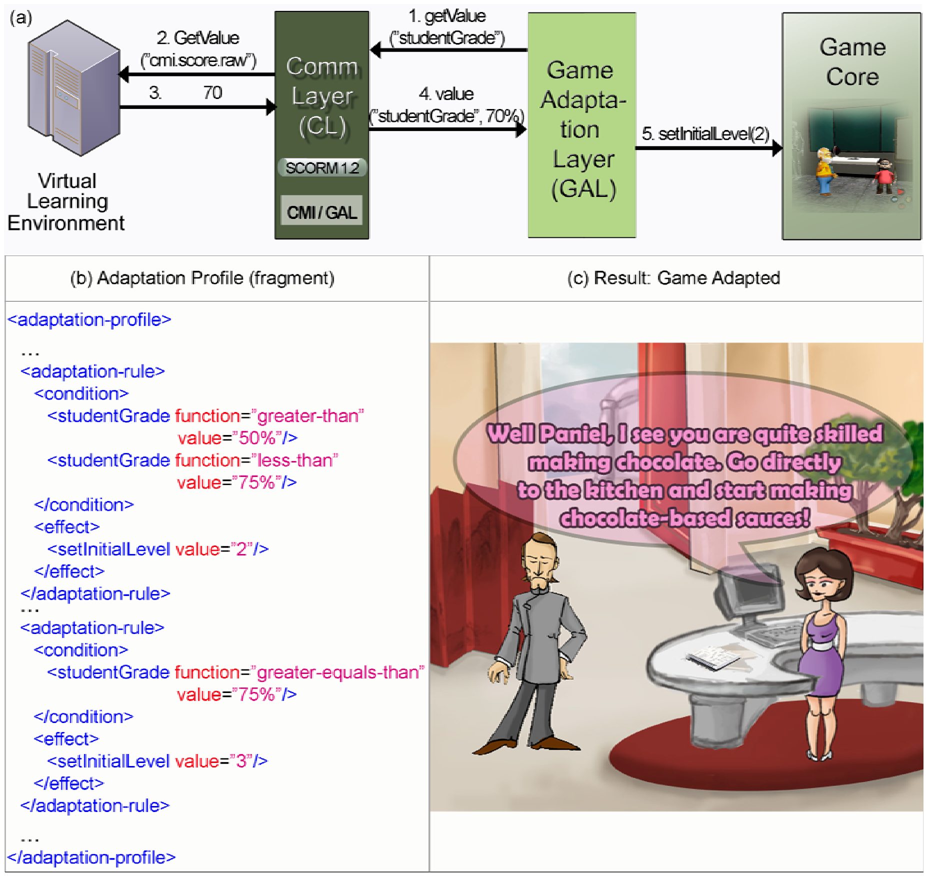

Fig. 3. (a): Communication example diagram between the two layers, the VLE and the game core. (b): Fragment of the adaptation profile used in the example. (c): Screenshot of the game adapted.

skipped. Finally, if due to any cause the overall grade could not be retrieved from the VLE, or if the overall grade is less than 50%, no levels are skipped (figure 4a-step 5).

Besides, the game includes an in-game test that produces a final grade. This abstract grade is translated to the appropriate fields of the SCORM data model and submitted to the VLE through the middle-ware, following the same steps (translation of the game concepts into abstract information and then translation into VLE-specific constructs). This grade can then be used in future executions of the game to make the initial adaptation decision.

5 Conclusions and Future Work

In this paper we have discussed the benefits that game-based learning can bring to e-learning in terms of adaptation and assessment. However, bringing both worlds together is a technically challenging task ought to the complexity of both fields. Especially relevant in this concern is the diversity of VLE communication and standards (SCORM, IMS LD, etc.) in e-learning.

Our contribution is a general architecture for the integration of games in VLE, consisting of a two-layer middleware which abstracts the existing standards. Using this architecture, the communication between a standards-compliant VLE and an adaptive educational videogame is independent of the specific game or standard. This allows game developers to create games without needing to be concerned with the internal details of each possible implementation of the student-centered VLE, focusing in this manner on the design of pedagogically relevant aspects. The interoperability, maintainability and reuse of the contents are addressed as the architecture is flexible enough to support new standards and revisions thanks to the notion of pluggable adapters.

We have tested this middleware in the <e-Adventure> educational game platform [14], which provides an authoring environment for educational games with special emphasis on the integration with VLEs [15], adding support for the APIs provided by the architecture. The preliminary results are promising, but also indicate some issues that will require further research.

On the one hand, adaptation is a complex issue. To exploit all the potential of adaptive game-based learning the abstract adaptation model must be extended and refined far beyond its current state. The discussion of how to adapt the content and in what circumstance it should be adapted is still an open research question. Moreover, the automatic detection of in-game situations which require adaptation deserves its own line of research.

On the other hand, the middleware must be expanded to include more modules for additional communication standards, including VLE-specific plug-ins for those environments that do not provide a standardized method for content-to-VLE communication. On the game side, we are also working on the implementation of the architecture for different game engines in different platforms.

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Understanding and Facilitating Student Bloggers: Towards a Blogging Activity Model*

Michael Derntl

Research Lab for Educational Technologies
University of Vienna, Austria
michael.derntl@univie.ac.at

Abstract. Since instructors have started recognizing the potential of Web 2.0 integration in web-based courses, blogs have been used to provide students with means of virtual communication, contribution, collaboration and community building. In this paper we aim to take another step forward by presenting and analyzing the integration of student blogs in an undergraduate computer science course on software architecture and web technologies: we implemented an LMS extension that acted as a course blog portal by collecting and displaying feeds of externally hosted blogs and logging usage data. Data analysis reveals that students who perform better academically also tend to participate more actively in the course blogosphere. Subsequently, we propose a blogging activity model, which aims to reveal and explain relationships between blogging activity variables—including peer visits, commenting and posting—to achieve a better understanding of lively blog communities in courses.

1 Introduction

Instructors with a passion for learner-centered education have recognized the potential of Web 2.0 integration in web-based courses—tools such as wikis, social bookmarking, or blogs offer means of collaboration, expression, communication, reflection and many more creative, spontaneous facets of participation and knowledge building in the off-campus space. Essentially, a blog is a personal web page that is updated periodically by the blogger through posting (typically short) hypertext entries. These entries are presented in reverse-chronological order to visitors, who are typically allowed to post comments to blog entries. Most blogs are hosted on publicly available, free blog hosting services that provide state-of-the-art features such as downloading web feeds for content syndication, creating permalinks, maintaining blogrolls, and enabling personalization of the blog page using all sorts of visual layouts and gadgets. The success of blogs can largely be attributed to the simplicity of blog technology [1] and process: a new personal blog is only few mouse clicks away, and posting a new blog entry is as convenient as sending an email.

As a form of communication supporting highly diverse personal motivations [2], blogs have been successful on the Web for over a decade now. Nevertheless,

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it appears that in educational settings we are still in a phase of collecting experiences. There are numerous studies and theoretical investigations available in the literature on successes and failures of integrating blogs into web-based or hybrid course environments [3]. Previously reported uses of blogs in education include, for instance, the facilitation of collaborative learning by having students publish their work in a blog and receiving comments, feedback as well as support by peers and instructors (e.g. [4,5,6]); offering the students a means of reflection of their work on assignments, results, and learning progress in e-portfolios (e.g. [7,8]); or simply as an alternative to "classic" means of web-based communication. Interestingly, few reports concede that the first-time introduction of blogs was a failure (e.g. [9]). However, as with any other technology, building up expertise requires time, resources, and thorough reflection of lessons learned. We need to go beyond the novelty of using blogs in education and towards building a solid foundation of successful practice based on research [10]. This paper aims to take a further step in this direction by reporting results of quantitative analysis of blogging and LMS log data during the application of student blogs in a computer science lab course. We present empirical observations on relationships between blogging behavior and student academic performance, as well as an initial proposal of a model of blogging activity within the course community. The model aligns different variables of blog participation (e.g., visiting peers, commenting, and posting blog entries) and tests the hypothesized relationships using obtained log data.

The paper is structured as follows. In Section 2 we describe the context of the course in which blogs were introduced. This is followed up in Section 3 by a presentation of design details of the blog portal, which we implemented as an extension to our LMS to provide a seamless integration of blogging activities into the LMS. In Section 4 we present findings obtained from quantitative analysis of collected data and propose a blogging activity model. In the last section, we discuss the findings and present a conclusion and outlook on further work.

2 Course Context

Course Description. The context of this study is a module on software architectures and web technologies in the third semester of the computer science bachelor study at the Faculty of Computer Science, University of Vienna. The module was held in winter term 2008 (i.e., from begin of October, 2008 to end of January, 2009); it consisted of a lecture course (2hrs per week) and a lab course (2hrs per week) running over the whole semester. While the lecture was used to present subject matter, the lab course was used for hands-on practice through team projects and individual assignments. The lab course was organized into several parallel groups, of which two were held by the author and are thus under investigation here. The lab groups were designed in a blended learning style, with weekly on-campus group meetings in the computer laboratory serving as "synchronization points", i.e. they were used for di+stributing and explaining new assignments, for presenting and discussing team project deliverables, for presenting solutions to individual assignments, and for solving any emerging subject-related and assignment-related problems and difficulties. However, most of the student workload on the assignments was due outside of the lab meetings. For handling these web-based activities we employed our home grown learning management system CEWebS [11].

Blog Integration. After moderately successful first steps using blogs in 2007 [12], the aim was to put more explicit emphasis on reflective issues, i.e. problems encountered, solution approaches, peer support, reflection on learning process and progress. The blogging guidelines as handed out to students and published on the LMS blog portal were as follows: "Use your blog to reflect on your problems, insights, and contributions during and after your task-related activities (project work, individual tasks) for the lab course. For example, you could ask yourself the following questions: What causes/caused me problems (and why)? Which solutions have I found/tried that could also be useful for my colleagues? Where was I unable to find a solution (and why)? What am I contributing to the team project? How do/did I approach the current problem? etc. The minimum requirement is one blog entry per person per assigned task."

As an additional measure, we discarded the LMS internal blogging tool and decided to host the student blogs on `Blogspot.com` (also known as *Blogger*, see `http://blogger.com` or `http://blogspot.com`), a free blog hosting service offered by Google. `Blogspot.com` comes with all the state-of-the-art features like maintaining a blogroll, personalization of the blog page, using trackbacks, posting comments, etc. To achieve a smooth integration of blogging activities into the course LMS, we implemented an LMS extension that acted as the portal to blogging activities in the course (described in more detail in Section 3).

Students. The students were third-semester undergraduates of the computer science bachelor study at the University of Vienna. The two groups (Group A and Group B) under study in this paper had $N_A = 24$ and $N_B = 19$ participating students, respectively, for a total of $N = 43$ with 19% females and a mean age of 24.11 years ($SD = 2.91$). The distribution of participants into two groups was *not* part of the study design; it was due to regulations at the University of Vienna, where each lab group may have a maximum of 25 participants. At the beginning of the course only 7% of the students did not know what a blog was; 40% of the students have already been reading other blogs at least once a month; and about 27% already had experiences with keeping an own blog.

3 The Blog Portal

There are two ways of hosting blogs in educational contexts: (a) within an LMS that offers a blogging tool, e.g. Moodle, or (b) outside of the LMS on an externally hosted blogging site such as `Blogspot.com`. In our case, the decision was to host the blogs externally to exploit all state-of-the-art blogging features as mentioned above. However, since the LMS was *the* platform for all web-based course activities, hosting the student blogs externally created one critical problem: exploiting blog community features would require each student to create his/her own complete blogroll on `Blogspot.com` or in some other external web feed reader application. This would create entry barriers for each individual student and might be perceived as being too cumbersome to manage and too detached from the course LMS. In light of studies which revealed that easy-to-use technology does play a major role for the success of employing blogs (e.g. [13,14]), we implemented an LMS extension that served as the *blog portal*. The main page of this portal included several sections:

– **Blogging instructions**: A brief paragraph outlining the blogging guidelines, which were also orally communicated in the early lab meetings.
– **Own blog**: Displays a hyperlink to the own blog on `Blogspot.com`. In the student view of the portal—which was otherwise identical to the instructor view—this section also included a link to the instructor's blog. Essentially, obtaining the URL to student blogs on `Blogspot.com` was the only obstacle to getting the blogging activities started in the course. Students who visited the portal for the first time were presented a form that advised them to create a new blog on `Blogspot.com` and to supply the URL to their newly created blog. To ensure a synchronized start of blogging activities in the course, we dedicated parts of one lab meeting to demonstrate how to create a blog on `Blogspot.com`, how to use the blog portal, and to explain the blogging guidelines.
– **Blog feed**: At three-hour intervals, the portal page asynchronously downloaded the RSS feeds of all student blogs. These feeds were backed up for analysis and the 20 most recent blog entries extracted from the RSS feeds were listed in this section of the portal. For each blog entry in this list the display included: title of the blog entry, author's name, author's lab group number, date and time, and the number of comments posted to the blog entry. The purpose of this list was to stimulate blogging activity by showing peers' blog entries and comments. A click on a blog entry title would redirect the user to the blog entry on `Blogspot.com`.
– **Course blogroll**: Displayed a list of students in each lab group; the names were hyperlinks to the blogs on `Blogspot.com`. This section was intended to enable easy access to all peer blogs.

All hyperlinks pointed to a proxy page, which first recorded the click in a log file and then immediately redirected the user to the target location. This way, the blog portal was able to log each portal visit and also each click on a hyperlink within the portal (including the timestamp, user, and relevant link-related information such as target blog, target entry, etc.). Thus the log files provide a comprehensive record of all actions taken on the blog portal.

4 Blogging Activity Analysis and Evaluation

This section presents results of the analysis of portal log data as well as blogging activities on `Blogspot.com`. To operationalize the concept of "blogging activity" we used several observable variables including number of blog entries, number

Table 1. Blogging and blog portal statistics

	Total		*Group A*		*Group B*	
	whole group	*per student mean (s.d.)*	*whole group*	*per student mean (s.d.)*	*whole group*	*per student mean (s.d.)*
Blogspot.com						
Blog entries posted	425	9.88 (6.52)	276	11.50 (6.97) *	149	7.84 (5.42)
Avg. entry length	–	825 (659)	–	939 (709) *	–	613 (533)
Comments received[a]	254	5.91 (8.40)	199	8.29 (9.08) **	55	2.89 (6.49)
Comments posted[b]	139	3.23 (6.12)	123	5.13 (7.46) **	16	.84 (2.34)
Portal						
Page visits	2,320	53.95 (84.2)	1,819	75.79 (104.4) **	501	26.37 (34.3)
Peer entry visits	1,914	44.51 (81.4)	1,590	66.25 (102.0) **	324	17.05 (27.7)
Peer blog visits	638	14.84 (16.2)	396	16.50 (17.6)	242	12.74 (14.5)

*$p < .1$, **$p < .05$ ... significance of difference of means between Group A and B.
[a] including instructor comments; [b] excluding instructor comments.

of comments received, number of comments posted, and relevant log data from the blog portal page, including frequency of portal visits and visits to peer blogs and blog entries. Using those data, we were able to distill each student's blogging activity profile. In this study we focus on quantitative data related to student blogging activities in the course and leave the actual blog contents out of analysis. Table 1 shows descriptive blogging statistics for all students of Groups A and B.

The table shows that each student on average posted close to 10 blog entries. The average blog entry was 825 characters long, i.e. about the length of a typical paper abstract. A total of 254 comments were posted to the student blogs, that is .6 comments per entry. The blogs and blog entries were accessed through the portal 638 and 1,914 times, respectively. The portal had a total of 2,320 page visits by students of both lab groups. During the blogging period (102 days) the student community posted an average of 4.17 entries per day. However, blog posting activity was not distributed evenly. Students had Christmas holidays of 16 days, where only one entry was posted per day on average. Posting activity peaked on days close to assignment deadlines and lab meetings. In the days on or before lab meetings (26 days) more than 50% of all entries were posted (averaging 8.2 entries per day). The other variables displayed in Table 1 also show substantial variance, which may be illustrated by a few simple facts: 12% of the students contributed almost two thirds of all comments to peer blogs; 28% of the students contributed two thirds of all blog entries; and 20% of the students accounted for half of all visits made from the blog portal. This kind of distribution of few heavy contributors, some active contributors, and a vast majority of lurkers is typical of online communities and has been described by Nielsen [15] as the "90-9-1" rule of participation inequality.

Correlation analysis using Pearson's r shows that there is a significant positive correlation between the overall score students received for assignments and the number ($r = .650$, $p < .01$) and average length ($r = .301$, $p < .05$) of their blog entries. There may be several reasonable explanations for this observation. One would be that students who achieve higher scores for their assignments presumably invest more time and effort into solving their assignments. This additional effort spent should produce more ideas, issues, solutions and other information to blog about. The blogging guidelines (see Section 2) advised students to post one blog entry per assignment. Even though the guidelines were not strictly enforced, better students tended to demonstrate more compliance. Rank correlation analysis using Spearman's *rho* showed that better students also more frequently visited their peers' blogs ($\rho = .466$, $p < .01$) and posted more comments to peer blogs ($\rho = .501$, $p < .01$). Thus, high-performing students tended to be more active in the blogosphere both actively (blog entries and comments) and passively (blog visits).

Based on a survey distributed at the end of the course ($n = 30$), we also tested whether previous experience with and knowledge about blogs had an effect on blogging behavior. Previous experience with reading other blogs and keeping an own blog, respectively, did not have any significant effect on the number of blog entries posted by students. Only two students did not know what a blog was at the beginning of the course—too few to calculate meaningful statistics. We also asked students whether blogging was perceived as a voluntary activity or as a duty. While students who perceived blogging as a duty did contribute fewer blog entries than those who voluntarily blogged, the difference was not statistically significant.

Individual blogging behavior in a course takes place within a community of peers. Students may be curious about what their peers are blogging, post comments to their peers' entries, and maintain blogrolls of their favorite peer blogs. To shed some light into such a community, Figure 1 displays the network of peer blog/entry visits in Groups A (left) and B (right). Each node in these graphs represents a student, whereby the size of the node grows in proportion to the number of blog entries posted by the student that is represented by the node. The thickness of the connecting edge between two nodes indicates the number of visits to the target peer's blog and/or entries via our blog portal. The figure reveals a substantial difference of peer connections in Groups A and B, which was already indicated in Table 1. Even though Group A had five students more than Group B, this could not fully explain the disproportions in the two group networks. To test this, we removed the top five bloggers from Group A data; even after this change there were still more than double as many peer visits in the network of Group A as compared to Group B.

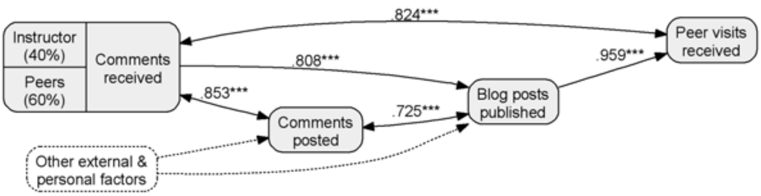
Blogging Activity Model. To achieve a better understanding of student blogging communities and their differences, we designed an initial model that aims to explain the relationships between various variables of activity within a blogging community. The proposed model, which is shown in Figure 2, is also intended to reveal spots in the community that offer instructors opportunities for facilitating and supporting blogging activity.

The main variables contributing to an active community of bloggers in the model are: number of comments and entries to blogs as well as number of comments received; all these can be observed directly on the blog hosting platform. The number of visits by peers to the own blog cannot be obtained from `Blogspot.com`, since this site does not offer access to any blog statistics. However, these figures can be estimated based on blog visits made through the blog portal. The hypothesized dependencies—indicated by arrows in Figure 2—are:

- Students who frequently posted to their blog tended to post more comments than students who posted less frequently, since both actions are similar forms of active participation. The actual data reveal a significant correlation between these two variables (Spearman's $\rho = .725$, $p < .01$).
- The more comments students received by peers, the more peer visits they attracted. This is obvious since, as described in Section 3, the blog portal displayed the number of comments of each blog entry in the list of recently posted entries. It should be safe to assume that (a) entries with comments attract more visits than those without any comments, and (b) this relationship is bidirectional, since each additional visitor will increase the chance of a comment being posted. This bidirectional relationship is confirmed by available data ($\rho = .824$, $p < .01$).
- Received comments also significantly stimulate the own blog posting activity ($\rho = .808$, $p < .01$). This relationship is unidirectional, since the reverse direction (influence of blog entries on comments received) is transitively covered in the model via the "peer visits received" variable.
- We expect a strong relationship between blog posting and peer visits, since each blog entry appeared (at least for some time) on the RSS feed of the 20 most recent entries on the blog portal. Actual data reveal an extraordinary high correlation coefficient of $\rho = .959$ ($p < .01$).

Our simplified blogging activity model reveals a simple yet effective spot that can be used by instructors / facilitators to spark and sustain blogging activity: "comments posted" is the only variable within the student community that is actually under co-control by instructors. From the student point of view, this effect is less obvious, since the blog portal does not reveal *who* commented on an entry; it merely shows *how many* comments were posted, which is anonymous until the blog entry is actually visited. So keeping external factors constant, the easiest way to facilitate bloggers would be to make inspiring comments to their blog entries. The model can also be used to try to explain the strong differences in activity within the communities of Group A and B evident from Figure 1. According to the model, the primary seeds of activity within a student blogger community are comments and peer visits. Table 1 shows that commenting and posting in Group B was significantly less frequent than in Group A. This would explain the low number of peer visits in Group B, and since fewer visits lead to fewer comments, the "vicious circle" in Group B was completed. However, there were additional factors which were obvious to the instructor. For instance, in Group A we had a handful of active, motivated bloggers who kept the activity at a high level and demonstrated how useful blogging can

Fig. 1. Networks of peer blog visits. (left: Group A; right: Group B).



$^{***}p < .01$

Fig. 2. Model of blogging activities in the course

be in supporting reflection and personal exchange. Without such bloggers, it might as well be impossible to spark and sustain blogging activity in the student community.

Related Models. We assume that in reality there will be many more factors—motivational, technological, social, and personal—which would contribute to individual blogging and community activity. Several researchers have tried to explain blogging behavior based on such factors. In [13], the authors propose a weblog success model based on content value (e.g., type of information, presentation, posting volume), technology value (e.g., tool characteristics), and social value (e.g., visitors, commentators, blogroll). In relation to this model, our model clearly focuses on observable, quantitative measures of social value in combination number of postings (content value). Another research model was recently presented in [14]: it shows that the intention to blog is dependent on factors of technology acceptance, knowledge sharing, and social influence. However, this model is primarily concerned with user intentions as surveyed through questionnaires, and it does in contrast to our model not deal with explanation of actual blogging behavior. In an effort to explain blogging behavior based on personality traits, Guadagno et al. [16] found that people who are open to new experience and who score high on the neuroticism scale are likely to blog.

Since the models discussed above show a range of different factors explaining blogging intentions and behavior, the obvious limitation of our model is that it does not consider personal and technological factors. Our model focuses on observable participation, that is, viewing, posting and commenting. Follow-up studies will have to investigate the impact of additional factors in our model.

5 Conclusions and Further Work

In this paper we presented a case study of using blogs in a blended CS lab course on software architectures and web technologies. Blogs were intended as a medium for reflecting on ideas, issues, assignments, and other things of relevance, as well as a tool for virtual community building. The blogs were hosted on `Blogspot.com`, a free blog hosting service, and integrated into our LMS by extending it with a *blog portal*, which downloaded RSS feeds of student blogs and displayed the recently posted blog entries and the course blogroll.

Analysis of blog usage on `Blogspot.com` and log data obtained within the blog portal showed quite diverse patterns of blogging activity. There were considerable differences in individual blogging behavior, i.e. posting entries to the own blog as well as visiting and commenting peer blogs. We discovered that students with higher academic performance tended to post more blog entries and comments, and they also tended to visit their peers' blogs more frequently. Similar results were found in a previous study in a similar context [12]. Thus, observed blogging behavior seems to be a good indicator of student performance, which could help instructors and facilitators in identifying "blog lazy" students as potential dropouts and/or low performers. Another finding was that blogging activity followed a ragged pattern, with activity peaks occurring close to approaching lab meetings and assignment deadlines.

In analyzing the network of peer blog visits in the two different lab groups under study, we found significant differences in frequency of peer visits, which could not be solely attributed to different group sizes. We devised an initial *blogging activity model* to assist in explaining the relationships between various activity variables within a network of student bloggers. Correlation analyses revealed that there was a circle of interdependence between receiving comments, visiting peer blogs, and posting to the own blog. This circle includes a spot that gives teaching staff opportunities to spark blogging activity, i.e. comments to student blog entries. These findings may have strong ties to the peer blog information we chose to display within the blog portal page. Further research is required to substantiate this proposition.

To obtain more qualitatively grounded conclusions and to overcome the narrow observation-based activity focus of the model, future research will address analysis and categorization of blog content, i.e. entry, comments, and personalized appearance of the blog page. The goal is to achieve a better understanding about who blogs, and why particular bloggers (or course sub-groups) have the capability of spawning high-activity communities of student bloggers.

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Enhancing the Social Capital of Learning Communities by Using an Ad Hoc Transient Communities Service

Sibren Fetter, Adriana J. Berlanga, and Peter Sloep

Centre for Learning Sciences and Technologies (CELSTEC),
Open University the Netherlands, Valkenburgerweg 177, 6419AT Heerlen, the Netherlands
sfe@ou.nl, abl@ou.nl, psl@ou.nl

Abstract. In online learning, communities can help to enhance learning. However, because of the dynamic nature of communities, attaining and sustaining these communities can be difficult. One aspect that has an influence on, and is influenced by these dynamics is the social capital of a community. Features of social capital are the social network structure, the sense of belonging and, the support received and provided. It is hypothesized that these features can be improved by using Ad Hoc Transient Communities (AHTCs). Through an AHTC learners are brought together for a specific, learning-related goal ('ad hoc') and for only a limited amount of time ('transience'). To test whether the use of AHTCs has a positive influence on the social capital, a learner support service which enables the use of AHTCs is proposed. Furthermore, requirements, prerequisites, and future research are discussed.

Keywords: Social Capital, Ad Hoc Transient Communities, Sense of belonging, Received and Provided Support, Peer Support, Social Network Structure, Learning Communities.

1 Introduction

Community formation in online learning environments has the capability to enhance learning [1]. An online community also gives participants a sense of belonging, provides easy access to other participants and prevents the feeling of isolation participants might experience [1-3], thus reducing the chance of participants dropping out [4-6].

However, since community formation is a dynamic process, it is inherently unpredictable [7, 8]. While communities need a certain amount of dynamism (e.g., participants come and go, information flow increases and decreases, etc.) to be able to emerge and stay in existence [4], too little or too much dynamism can again have adverse effects such as a low information flow or a high drop-out rate [9, 10]. One aspect of communities that influences and is influenced by these dynamics is the social capital [11]. Social capital represents the participant's relationships within a social network, as well as the mutual support between participants [12]. The features of social capital include: (1) the social structure of the network – how are participants connected - [2, 13], (2) the sense of belonging to the community [6, 14-16], and (3) the social support received and provided [17].

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In order to improve the social capital of online learning communities, we hypothesize that each feature mentioned above needs to be improved upon. With regard to these improvements the concept of Ad Hoc Transient Communities (AHTCs) seems very promising. Sloep [18, 19] introduced the concept as a means through which learners are brought together for a specific, learning-related goal ('ad hoc') and for only a limited amount of time ('transience') [19, 20]. In particular, Van Rosmalen et al. [18] tested a peer-support service that created Ad Hoc Transient Communities, through which participants were able to receive support from their peers within an online learning community. The results of this research seem to indicate that AHTCs have a positive influence on the social support received and provided. However, because of the novelty of the AHTC, there is no evidence on the effects AHTCs might have on the social structure of and sense of belonging to the community.

Fetter et al. [21] hypothesize that the use of AHTCs not only improves the support aspect of social capital, but also has a positive effect of the social network structure and sense of belonging. To test for these effects, as well as further extend the previous findings by Van Rosmalen [18] it is suggested to use AHTCs in an existing online learning environment and test for the effects on the social network structure, the sense of belonging, as well as on the support received and provided. By introducing AHTCs we aim to improve the social capital of the learning community in three ways. First of all we aim to improve participants' connectivity. Secondly, we expect the threshold to make and fulfill request will become lower for new participants. And thirdly, we expect to increase the effectiveness of the community as whole.

In order to facilitate the testing of these hypotheses, a service needs to be constructed that allows the emergence and tracking of AHTCs in learning communities. In this paper the outline of this service is introduced, as well as the requirements and pre-requisites needed for the service to be effective. First some theoretical background is given, followed by a concise explanation of the AHTC concept. Subsequently, the service is described and finally conclusions and future research plans are presented.

2 Social Capital

Social capital represents the relationships amid participants within a social network, as well as the mutual support between participants [12]. These 2 aspects can be split up into multiple factors that influence and are influenced by the amount of social capital of the community. These factors are the social network structure, the sense of belonging to the community, and the support received and provided.

2.1 Social Network Structure

The social network structure is an integral part of the social capital [13]. It represents how participants are connected to each other as well as how (sub-) communities are interconnected. These connections (or relationships) allow information to flow throughout the network and to the acquisition of new or the reinforcement of existing social contacts [22]. When looking at the quality of the social network structure there are multiple factors to take into account, for instance:

- The number of connections [22]
- The strength of the connections, within and in between communities [23]
- The spread of the connections [24]

Combining these factors gives a better view of the quality of the social network structure and provides insight into possible bottlenecks. One of these bottlenecks occurs when a small core group of very active participants makes the community prone to becoming instable [21]. Because most communication and activity goes through the core participants, the loss of one or more of them may well disrupt the communication and information-flow throughout the whole community. Participants can become isolated when they are only connected to a core person. A community which is dependent on a small group of core participants is said to be highly centralized [24].

High centralization brings another problem in its wake. In a highly centralized network core participants are the contact persons for most other participants. This will easily lead to the core participants being flooded with requests. This is problematic because it has been shown that participants are more likely to stop participating if they become overloaded with information [9].

In summary, for the social network structure to have a positive influence on the social capital, there should be (a) connections between participants that (b) should consist of weak and strong ones, which (c) should be spread out in a decentralized way.

2.2 Sense of Belonging

The sense of belonging or sense of community is an important feature when considering the social capital [16]. Participants need to feel part of the community, feel they have peers they can trust [25] and are able to collaborate with and / or ask for support [6, 14]. A low sense of belonging can lead to feelings of detachment, isolation, distraction, and lack of personal attention, heightening the chance of participant drop-out [4-6]. Drop-out is an important problem for online learning communities; it is often 10 to 20 percent higher than it is for learning communities where participants meet face to face [6, 26, 27]. Improving the sense of belonging is not only positive for reducing drop-out. It has also been shown to increase the students' involvement in community activities, improve retention, as well as encourage them to make more contacts [6, 28].

2.3 Support Received and Provided

Support is an aspect of social capital tied to knowledge sharing actions within a community. According to Lesser, Fontaine and Slusher [29] actions of mutual support positively influence the social capital in two ways. First, the support given and received becomes a sort of informal currency. It allows participants to validate each others' performance and willingness to help. Second, the combined efforts result in a more positive view on the community as a whole, especially when subjects are closely linked. Additionally, for social capital to be useful, it needs to be maintained, by reestablishing, sustaining, and creating relationships between people [12, 25], for instance through receiving and providing support.

In order to bring participants together as well as being able to provide the support necessary participants can be invoked as peer-tutors. This even has the added benefit that collaboration with peers can be a valuable method for both parties to improve learning [30]. In line with these considerations Van Rosmalen et al. [18] tested a peer-support service that created Ad Hoc Transient Communities, through which participants were able to receive support from their peers.

3 Ad Hoc Transient Communities

Through an Ad Hoc Transient Community (AHTC) participants are brought together for a specific goal ('their ad hoc ness') and for only a limited amount of time (their 'transience') [19]. Berlanga et al. [20] summarize the features that characterize ad hoc transient communities as follows:

- the self-organizing powers of the community and the absence of hierarchies
- the negotiation processes that the members engage in
- the members' expectations of the actions and behavior of their fellow members
- the work of the members towards a set of goals through united actions
- the emergence of relations of swift trust between the members

Van Rosmalen et al. [18] used a question and answering module to create an AHTC within a course on basic computer skills for informal, lifelong learners. In the study, individual learners could ask a question to their peers. Using a matching mechanism, two peer-learners were selected to act as tutors. Their selection was based on several criteria such as availability, content competency, and eligibility [18]. The participants selected would then deal with the question within a private wiki. The experiment showed a positive effect on learning when selecting peers at random for the AHTC (control group). However, the effect proved to increase when using the matching mechanism for the peer selection (experimental group). Its use significantly increased the responsiveness, quality of the answers, and perceived usefulness [18]. So in this particular case, the use of AHTCs improved the support feature. However, the study did not look into possible positive effects of AHTCs on the social network structure and / or the sense of belonging. This is what we now aim to investigate.

4 AHTC Service Outline

As mentioned before, our main assumption is that learning communities will benefit from using AHTCs, by improving the social capital of the learning community. To support our claim, we have to investigate three issues. The first issue is to investigate whether using AHTCs will decentralize the social network structure. By spreading out the (often numerous) requests over multiple participants through matching, it is expected that a multitude of relationships will be in effect within a short period of time. By making sure that most participants are not just connected to a central participant a case of drop-out does not so easily lead to sudden isolation.

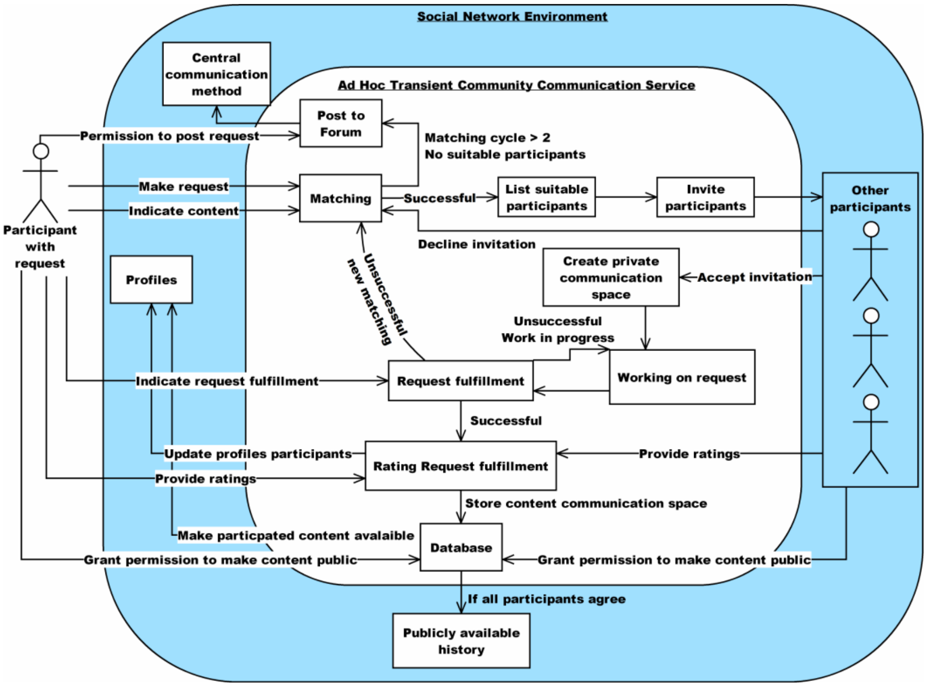

Fig. 1. AHTC service

Second, by providing a way for participants to easily meet each other through the AHTC, we expect the sense of belonging to the community to increase. This applies especially in the beginning, when participants might feel reluctant to ask questions because they feel incapable of returning the favor. However, with AHTCs participants are capable from a very early stage on to fulfill requests from others: Because the moment the participant has some content competency, she could already be matched to others without that competency.

Third, the support that is received and provided will give meaning to the community. The fact that knowledge is shared and requests are fulfilled is not only a goal, but also an influence by itself. It defines the effectiveness of the community as a whole, as well positively influences factors such as the sense of belonging [29].

In order to test whether the use of AHTCs will have the sought after positive effects on social capital, a learner support service which facilitates AHTCs is needed (see Figure 1). Through this service, participants will be able to make requests for collaboration and support. As can be seen below in Figure 1, whenever a participant has a request a matching mechanism is set in motion that searches for peers that fit the request. In case of a successful match, participants are invited to a private communication space where the request can be fulfilled. Once fulfilled, the participants are asked whether they are willing to make the result publicly available in a 'frequently asked question' (FAQ). Below, each part of the service is explained in more detail including some considerations.

Request – Each request will be entered through a form within the social network environment. The participant types in the request and selects from a drop-down menu to which content the request belongs.

Matching – Based on participants' availability and content competency values, a 'matching score' is calculated. Based on this score, a list of participants most suited to support the request is created. Starting from the top of the list (highest matching scores), two participants are invited through e-mail. In case of a decline the next participant on the list is invited.

Environment – Upon the acceptance of a request, a private space is created, accessible only to the participants involved. Depending on the possibilities of the social network environment, the space can have different forms, such as a wiki or a forum space. This space will always include the text of request, selection boxes to indicate request fulfillment, as well as having access restrictions. Only the participant who made the request as well as the participants that accepted the invitation are allowed access to the private space.

Request fulfillment – The request will be handled as dealt-with (successfully or unsuccessfully) once the participant that made the request indicates this to the system. In case of an unsuccessful fulfillment, either a new AHTC is created or the participant is asked for permission to post the request via the publicly available communication method. This way, it is hoped that other participants who were not matched, might still fulfill the request.

Ratings – Once a request has been dealt with, all participants are invited to rate the quality of the request fulfillment (1- very poor to 10- excellent).

Storage – The request, all communication in text format, and ratings are stored in the database and stay available for the participants involved. The profiles of the participants are updated based on the ratings, and request fulfillment. The profile page thus will show how many requests someone has fulfilled and the average quality of these answers. Furthermore, a private link is provided for the participant to quickly access the history of any request they were involved in. With each of these entries, all participants involved are asked whether they agree to make the content of the AHTC publicly available. If all participants agree, the content is posted to a publicly available history in the social network environment.

5 Conclusions and Future Research

As has been argued, we expect the use of the proposed AHTCs learner support service has a positive effect on the learning community as a whole and, particularly, on the social capital of the participants. It is hypothesized that AHCTs help to decentralize the social network structure, strengthen the sense of belonging, and intensify the support received and provided. In this paper we have presented how AHCTs should be designed. Based on the proposed design, future research includes simulations to validate the design as well as the development of a prototype for actual experimentation. Once the prototype has been built and tested, a final longitudinal experiment will be conducted in an existing online learning setting.

Acknowledgment

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Learning Resources Organization Using Ontological Framework

Tatiana Gavrilova[1], Vladimir Gorovoy[1], and Elena Petrashen[2]

[1] Saint-Petersburg State University, Graduate School of Management, Information Technologies for Management Dpt. 199004, Volkhovsky, per. 3, St. Petersburg, Russia
tgavrilova@gsom.pu.ru, gorovoy@gsom.pu.ru
[2] Saint-Petersburg State Polytechnic University, School of Information Technologies, Politechnicheskaya, 29, 195251, St. Petersburg, Russia
elena.petrashen@gmail.com

Abstract. The paper describes the ontological approach to the knowledge structuring for the e-learning portal design as it turns out to be efficient and relevant to current domain conditions. It is primarily based on the visual ontology-based description of the content of the learning materials and this helps to provide productive and personalized access to these materials. The experience of ontology developing for Knowledge Engineering coursetersburg State University is discussed and "OntolingeWiki" tool for creating ontology-based e-learning portals is described.

Keywords: e-Learning, e-Learning Objects, Ontologies, Subject Domain, Wiki-technology.

1 Introduction

As e-Learning is a cross discipline artifact that spans sociology, philosophy, psychology, pedagogy, artificial intelligence and human computer interaction, a technical solution which is a result of a system development should be carefully processed from the point of view of mentioned disciplines. The society becomes more and more visually dominated [1], new economy requires efficiency, just-in-time delivery and task relevance – this is why educative systems need to become more up-to-date, flexible and adequate. And often pedagogical and psychological construction and delivery of the content are even more important than the actual content.

Using ontologies in building educational systems is not really a new concept as they have often been used to represent different concepts to be taught in a course [2].

However, the importance of specification and structuring the content and its visual presentation – followed with such connected issues as design, adaptation and usability has been underestimated to a certain extent until recent times as the researchers were far more concerned about how to educate (with methods of instruction or reasoning over the content) than how to present the object of the research (content specification and knowledge structure) [3]. So constructing ontologies to form content and/or navigation system, improving navigation usability and level of knowledge acquisition is rather new and promising field. In recent years, there has been a growing interest in ontology enginering strongly motivated by the Semantic Web initiative [4].

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In this paper we describe the experience of ontology developing for Knowledge Engineering course using our ontology- and wiki-based tool OntolingeWiki for presenting the ontology and orchestrating information related to its concepts.

2 Ontological Framework: A Brief Overview

In the context of e-learning the conceptual structure of the content presented in ontology helps learner to integrate the concepts that he/she is trying to learn and understand. This is where the Semantic Web principles are vital and ontological reasoning is a promising tool to provide a formal description for a shared explicit domain conceptualization [2, 5, 6]. It also facilitates knowledge patterns and learning resources sharing, adapting and reuse [7, 8, 9].

Ontological framework makes possible to use different structures to overcome the one-size-fits-all approach and to personalize learning process.

A visual presentation of course's structure which is presented by a top level ontology permits also to boost quality of learning process. As two major problems perception in e-learning are loss of overview due to low information density of the medium and short attention spans due to fast fatigue of perception structure and presentation of learning material it will be a lot more effective if it reflects the characteristics of hypermedia and the web [10].

3 Knowledge Engineering Ontology

Our first step was creating a visual representation of the top level of ontology as a powerful mind tool in structuring process. Its concepts are tied with self-contained chunks of training content – learning objects. This targets reusability since these learning objects can be reassembled later to create other courses just as well to personalize this one for different types of learners (e.g. for different proficiency degrees students etc). Visual form influences both analyzing and synthesizing procedures in ontology development process [11, 12]. Also this is important as e-learning systems require unambiguous and complete learning design [13]. The developed ontology will be also used as a table of contents for educational system.

The required qualities for the domain knowledge ontology are:

- Accuracy
- Completeness
- Cognitive adequacy [14]
- Conceptual balance [5]

It's also important to exclude excessiveness and contradictions and to avoid it being too complex and/or big. The solution how to combine first and last demands is to make it more scalable – e.g. when user chooses the leave of top level ontology it proves to be the root of another one – the screen is not overloaded so the information is perceivable yet all the advantages of using ontology are kept (see fig.1).

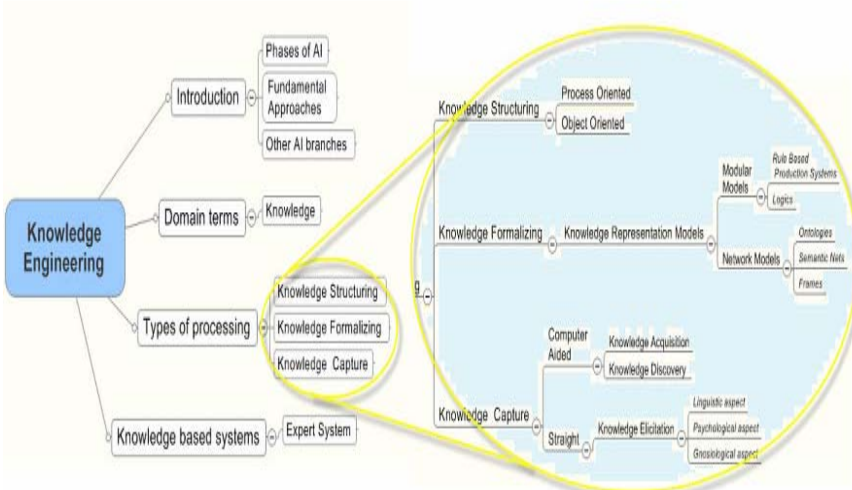

Fig. 1. Top Levels of the Educational Ontology of Knowledge Engineering, node can be opened to present nested data

4 OntolingeWiki – Technology for Creating e-Learning Systems

Our ontology is presented and managed using OntolingeWiki. OntolingeWiki is a tool that takes advantage of both wiki-technology which targets perfectly collaborative development and ontologies as a tremendous tool for knowledge structuring. It can take any ontology saved in OWL format as an input and provide web-interface for ontology navigation with visualization based on hypergraph technology (http://hypergraph.sourceforge.net). Each concept of the ontology can be annotated with wiki-page created on demand (see http://ailab.ifmo.ru:8081/). OntolingeWiki was created on the base of Ontolinge-KAON system [15].

This technology can be used for creating ontology-based educational portals and was successfully leveraged in the design of the ontology-based content management system for the virtual exposition of the optical technologies museum in Saint-Petersburg State University of Information Technologies, Mechanics and Optics. Many electronic teaching materials such as presentations, animations or java-applets were united in the virtual exposition which introduces a visitor with optics according to the chosen ontology model.

5 Summary and Future Work

The domain ontology proposed in this paper has a wider objective to provide a framework to describe the course as ontology-based conceptual modeling makes content more comprehensive for an individual and technologically it provides concrete and stable database. Knowledge systematization and coordination also permits to boost quality [9]. But the usability and appropriateness of this ontology should be further investigated and refined accordingly.

We observe the developed ontology as a promising starting point towards achieving a fully functional adequate and up-to-date computer-based educational system where it's going to be used as a domain knowledge representation model. We consider OntolingeWiki tool as a step forward in creating a useful technological environment for creating ontology-based educational portals supporting collaboration.

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Social Reference Model for Adaptive Web Learning

Fawaz Ghali and Alexandra I. Cristea

Department of Computer Science, University of Warwick,
Coventry, CV4 7AL, United Kingdom
{F.Ghali,A.I.Cristea}@warwick.ac.uk

Abstract. In this paper, we describe the design steps of extending LAOS, a five-layer framework for generic adaptive web learning authoring, by adding a social layer to capture (and adapt) information from 1) *collaborative authoring* (i.e. editing the content of other learners, describing the content using tags, rating the content, and commenting on the content, etc); and 2) *authoring for collaboration* (i.e., adding authors' activities, such as defining groups of authors, subscribing to other authors, etc). Moreover, the paper presents MOT 2.0, an adaptive E-learning 2.0 system, which is built on the proposed reference model, and finally, we report on our evaluations to validate the new *Social Layer* by comparing MOT 2.0 with its predecessor, MOT 1.0.

Keywords: Social LAOS, Adaptive Web Learning, MOT 2.0.

1 Introduction

Over the past decade, the Web has constantly evolved. Since the early 2000s, many applications rely on the users and their relations more than on the information itself. A large part of the modern web, the *Social Web*, is powered by the users, as its information is produced by them rather than by websites owners.

Conversely, *personalization* has been an important trend for almost 40 years now if we speak of user modelling [17], almost 30 years if we refer to intelligent tutoring systems [18], and almost 20 years since adaptive (educational) hypermedia systems (AEH-S) arrived [2]. From the late 1990s, adaptive A(E)H-S research took a more systematic approach, and a set of reference models have been developed. Still, these models do not include the recent expansion of social activities in their architectures.

In this paper, we briefly discuss previous models and frameworks, to highlight the motivation behind extending LAOS, a five-layer framework for generic adaptive (educational) hypermedia authoring, by adding a new *Social Layer* to capture and adapt information collected from 1) *collaborative authoring* (i.e. editing, describing, rating other users' content, etc); and 2) *authoring for collaboration* (i.e., adding author activities, e.g., defining groups, subscribing to authors, etc). Moreover, we validate the new *Social Layer*, by developing MOT 2.0, an adaptive e-learning 2.0 authoring and learning system for AEH, and we report on our comparative evaluations with MOT 1.0 [6], a previously built A(E)H authoring tool.

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2 Models of Adaptive Hypermedia

Many adaptive (educational) hypermedia systems have been launched since the early 1990s; in the late 1990s, structural design for adaptive hypermedia systems started to appear. In this section, we analyse similarities and differences of these models.

1. The Adaptive Hypermedia Application Model (**AHAM**): AHAM [9] is based on the Dexter model [13], a reference model for hypertext systems. AHAM consists of: the *Run-time Layer*, the *Storage Layer* and the *Within-Component Layer*, connected by the interfaces *Presentation Specifications* and *Anchoring*. The Storage Layer has three sub-models: 1) *the Domain Model* that consists of a set of concepts and concept relationships; 2) *the User Model*, containing concepts with attributes storing user preferences; 3) *the Adaptation Model* with adaptation rules that use the attribute values of concepts in the user model in order to determine if and how to present concepts and links from the domain model.
2. The **Munich Reference Model**: [14] is an UML-based visual model similar to AHAM (although independently developed). Just like the AHAM model, the Munich model represents prerequisites in the domain model and bases its domain structure on pages, adding information about how the content will be presented to the final user directly in the domain model.
3. **WebML**[5]: is also a visual language, like UML, but specifically designed for describing the content structure of web applications. WebML has four orthogonal perspectives: 1) *Structural Model*: describes the content in terms of the relevant entities and relationships; 2) *Hypertext Model*: describes how the contents are published on the application hypertext [4]; 3) *Presentation Model*: describes the layout and graphic appearance of pages, independently of the output device and of the rendition language, via an abstract XML syntax; 4) *Personalization Model*: describes users and their organization in groups in the form of entities and defines personalization based on these entities.
4. The XML Adaptive Hypermedia Model (**XAHM**): XAHM [3] is an XML-based model for AH systems, with an *application domain* -, a *user* - and an *adaptation model*. It is composed of a *graph-based layered model* for describing the logical structure of the hypermedia, and *XML-based models* for describing the metadata on basic information fragments and "neutral" pages to be adapted.
5. The Goldsmiths Adaptive Hypermedia Model (**GAHM**) [16]: is a conceptual model with three groups of functions: 1) The *H-region functions* that model non-personalisable hypermedia-based interaction, where hyper-pages are represented as formal specifications; 2) the *P-region functions* that model user-initiated tailoring of hypermedia content; 3) the *A-region functions* that model system-initiated tailoring of hypermedia content.
6. The Generic Adaptivity Model (**GAM**) [10]: is a *state-machine*-based model. At each interaction an event gets generated. This event induces an action that results into a state change in the system, which can be parameterized by external values. A user model can be the source of such values. Compared to AHAM, GAM is a more low-level model and does not provide hypermedia specific concepts.
7. The **LAOS framework** [7]: is a general framework for authoring of A(E)H, based mainly on the AHAM model, presenting however some features of the WebML language, in that it has a presentation model. It consists of: *Domain Model* (DM),

Goal and constraints Model (GM), *User Model* (UM), *Adaptation Model* (AM) and *Presentation Model* (PM). LAOS differs from other modules as follows. LAOS introduced the *GM* model. This layer stores the original aim of the adaptive hypermedia, from the perspective of the designer, or teacher, in learning environments: thus, pedagogic information; or business logics for commercial sites, something that was missing in previous models (see [7]). Furthermore, LAOS's AM model is different from that of AHAM. The adaptation model is based on the LAG model [8], a three layer model for authoring adaptation, which allows different entry and reuse levels for adaptation specification, depending if the author has programming skills or not. Thus, the initial threshold for creating adaptation is lowered. The major difference to AHAM (and other models) is a higher level of reuse, due to the clear separation of *primitive information (content* – in the DM*)* - and *presentation-goal related information* (e.g., pedagogical information in educational systems and prerequisites in the GM). In this way LAOS facilitates a high degree of information reuse, by separating information from its specific context. Another important difference to AHAM is given by the notion of 'concept' used in the domain model. In LAOS, concepts have different representations defined via attributes, and are restricted to represent a *semantic unity* (unlike in AHAM). This is further enforced by allowing only self-contained attributes (without direct or indirect dependencies). Unlike some of the other models, such as XAHM or GAM, LAOS does not prescribe a unique representation for each layer, but just specifies its contents. Thus, each layer could be represented via databases, XML, state machines, etc. Moreover, the adaptation model, LAG, only specifies the different entry levels for reuse (whole strategy, high level adaptation language patterns, or low level adaptation 'assembly' language patterns such as IF-THEN rules) but does not enforce a specific language[1]. For these reasons, we have selected the LAOS framework for further development in our research, as discussed in the following.

3 Social LAOS

None of the previous models, including LAOS, have modelled or included social activities from the Social Web, which focuses on the relations between the users (learners and authors in this paper's context), and their collaborative activities[2]. In addition to information stored in previous models, social annotation can be used to recommend adaptive materials for the delivering/authoring process. The aim behind including collaborative authoring and social annotation in LAOS is to define improved adaptive (educational) materials based on communities of practice [20].

Authors who share the same interests can collaborate to provide more valuable adaptive educational content within their communities, based on their different backgrounds and knowledge. The collaborative facilities in the *Social LAOS framework* rely on Web 2.0 techniques, such as group-based authoring, cooperation in creating

[1] Some implementations exist, i.e., the LAG language [8], or the LAG-XLS language [19].
[2] Although the GAHM [16] comes closest to it.

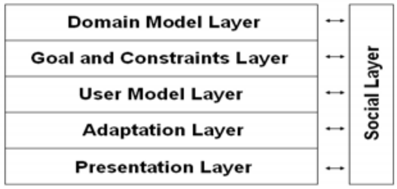

Fig. 1. Social LAOS

the courses, tagging (labelling) the learning content, rating it, and feedback. The collective learning content works as a *state-based system*, as each particular instance of it can be used to improve the authoring process, by recommending *related learning content* to authors, which then can decide on the next state of the collective content based on these recommendations. Additionally, *related authors* (i.e., authors with same interests) can be recommended, who can help in the authoring process.

Furthermore, in the Social LAOS framework, teachers are no longer the only authors of the learning content; students can also be authors, as they too can add their contributions, controlled by a set of privileges set by the teachers. Fig.1 illustrates the addition of a new layer, the *Social Layer* onto LAOS, expressing all social activities within AEH-S. These social activities include, but are not limited to 1) *collaborative authoring* (i.e. editing learning content of other users, describing it using tags, rating, commenting on the content, etc); 2) *authoring for collaboration* (i.e., adding author activities, e.g. defining author groups, subscribing to other authors, etc); 3) *group-based adaptive authoring* via group-based privileges; 4) *social annotation* i.e., tagging, rating, and feedback on the learning content via group-based privileges.

The *Social Layer* is defined vertically, and not horizontally, as it affects all other layers directly. For example, the *Domain Model Layer* will include new entities to describe tags, feedback, comments, rating of the learning concepts, and the relations between these concepts. *The Goal Model* will include new entities to describe the new constrains on the social activities, i.e., determining who can do what. Moreover, the *User Model* will contain new entities to describe the groups and the roles (privileges) on these groups. Additionally, the *Adaptation Layer* will hold new entities to handle the collaborative adaptive strategies. Finally, the *Presentation Layer* will also contain new entities to describe how to present information to group of users. More information about how the social information can be represented in the various layers of LAOS can be found in previous work [12].

4 Implemented Example: MOT 2.0

In the following, we show for exemplification the definitions of the Social Layer for a specific new system developed at the University of Warwick: the MOT 2.0 system, an adaptive e-learning 2.0 authoring and learning system for AEHS, previously described in [11]. MOT 2.0 is loosely based on the MOT 1.0 authoring system for AEHS [6], but it goes beyond it, as it not only incorporates social aspects, but it also, by removing the boundary between authoring and learning, becomes both an authoring as well as a learning system. The screenshots presented below demonstrate different functionality and features of MOT 2.0, as follows.

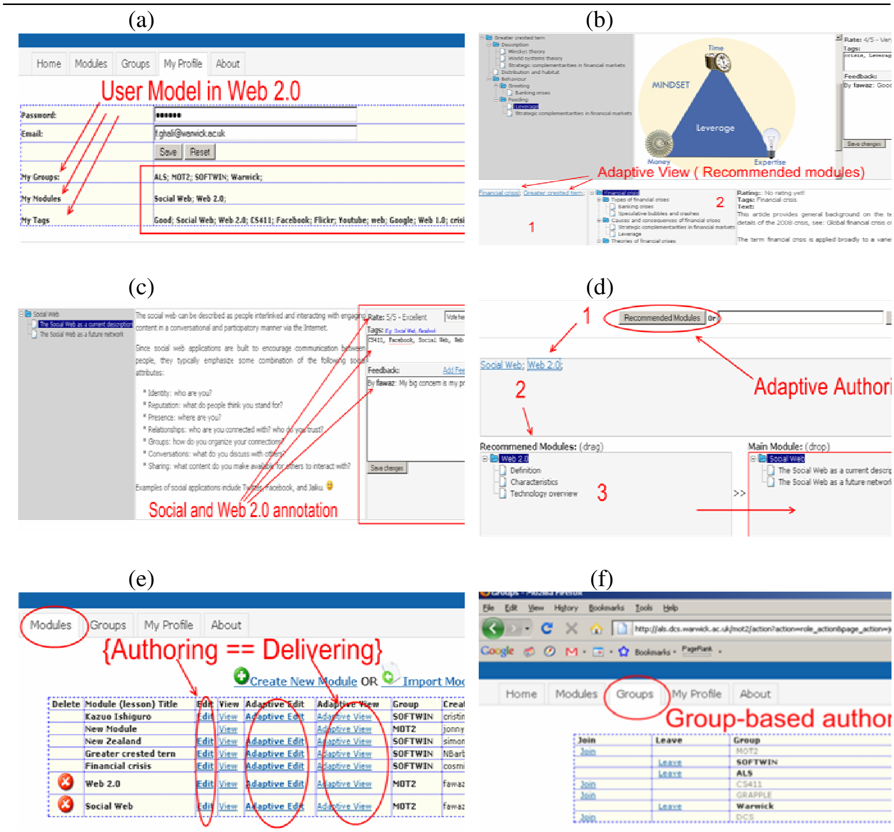

Fig. 2. MOT 2.0 Screenshots

Figure 2 (**a**): the user model captures the results of all actions the users (tutors and learners) made using MOT 2.0, which facilitates creating the user model in the Social Web; these action results contain which groups the user has already subscribed to, what modules the user has created/edited, what tags the user has already used and for which module. In future version, MOT 2.0 will capture more information, such as user's subscribers, user's subscriptions, user's ratings, etc. Figure 2 (**b**) expresses the *adaptive view of the lesson*, which shows other related recommended materials for further reading based on the similarity of the tags (keywords that label the content); in the following implementation round, we plan to apply other adaptive strategies, as the specification of the strategy will be external and exchangeable, according to the LAG model [8]. Figure 2 (**c**) describes the *social annotations* for the actual lesson based on the user's privileges for the selected group/course. These social activities include: rating the content of the item, feedback, and tagging items with a set of keywords. These social activities are captured and added to the user model in order to provide more adaptive features, and thus more flexibility in the adaptation process. In such a way, the recommended content is based not only on the background and trace of the user, as in classical adaptive hypermedia, but also on social activities, e.g., on how popular the item is with other readers, on who recommends it (e.g., trusted users versus unknown users), etc. Figure 2 (**d**) shows how the *adaptive authoring* works, by displaying other related recommended courses which can be used in creating the course. In future version, the authoring process can use different adaptive strategies as defined by the LAG model. Figure 2 (**e**) is about *merging the authoring and the learning* processes, as the users may still change the content of the course during or after the learning, or they may annotate it during its creation. This explains why adaptive strategies can be applied not only for the learning process, but also for the authoring one. Figure 2 (**f**) shows the *group-based authoring* concept, where users can create groups, and have different privileges on different groups. This setup allows the definition of advanced levels of the relation between tutors and learners based on the latter's user model. In future version, MOT 2.0 will update the privileges automatically and semi-automatically, based on the user model.

5 Evaluations and Discussion

The new *Social Layer* and MOT 2.0 as presented above have been evaluated with the help of 1) a group of eight *course designers* from Softwin, an e-learning company in Bucharest, Romania, in addition to 2) a group of seven *students* studying 'Dynamic Web-based systems', a 4th year module in the department of Computer Science at the University of Warwick, UK. The course designers and the students were separately introduced to the system after they had a few lectures on adaptive hypermedia, user modelling, semantic web and social web. The aim was to find out what added value the instantiation of the *Social Layer* in LAOS could bring to an authoring system. Thus we analysed MOT 1.0, the prior authoring-only environment for adaptive hypermedia engineering that is built based on LAOS, versus MOT 2.0 that is built based on the Social LAOS, which includes the *Social Layer*. For evaluating authoring environments, the ideal is to use course designers, who are experts in e-content-based courses. This group of users was represented by the Softwin group. However, as MOT 2.0 blurs the borders between authoring and learning, it was necessary to get feedback from the other end of the spectrum as well, thus from students, as represented by the Warwick group of students.

The evaluations reported here are based on the comparative analysis of *two stages of experiments*. The first stage involved two experiments, one carried out by the course designers and one by the students, separately, each consisting in participants following five scenarios within the authoring system for adaptive hypermedia MOT 1.0 [6] which is based on the LAOS framework. Similarly, the second stage involved two experiments, also carried out by the course designers and the students respectively, this time using MOT 2.0, which is based on the Social LAOS framework. In the second stage, the course designers and the students were asked to perform some standard authoring tasks as in MOT 1.0, as well as specific new tasks with the MOT 2.0 system, which highlighted the new *Social Layer*. These tasks involved reusing the adaptive lectures that they had created previously, as well as creating material from scratch, and, of course, using the social tools (rating, tagging, feedback, etc.). The two stages were carried out in the same year, separated in time by the period it took to build MOT2.0.

Table 1. Questionnaires statistics. M: Means (1 - 5); SD:Standard Deviation.

Questions: *What do you think about*:	**MOT 1.0 Designers**	**MOT 2.0 Designers**	**Probability** (p <=0.05?) **Designers**	**MOT1.0 Students**	**MOT2.0 Students**	**Prob-ability** (p <=0.05?) **Students**
browsing other author's domain maps?	M: 4.50 SD: 0.76	M: 4.38 SD: 0.74	**p=0.76** *for* **Diff** = 4.38-4.50 =-0.12	M: 3.71 SD: 0.95	M: 4.71 SD: 0.49	**p=0.06** *for* **Diff** = 1.0
keyword-based access for other authors' content?	M: 3.5 SD: 0.93	M: 4.25 SD: 0.71	**p=0.08** *for* **Diff** = 0.75	M: 3.29 SD: 1.5	M: 4.14 SD: 1.21	**p=0.05** *for* **Diff** = 0.85

After performing each experiment, participants in all experiments were asked to respond to specially neutralized questions[3] as exemplified by the two questions in Table 1. The bulk of the questions were kept identical in the two stages of the experiments, in order to compare the two systems, representing the initial LAOS framework and the extended Social one. A few extra questions were added in the second stage, in order to extract feedback on some specific issues related to the social aspects. However, here we concentrate only on the identical set of questions and its comparative results. The table also shows the *mean* value of their response on the scale of 1-5 (*(not at all useful) 1 2 3 4 5 (very useful)*), as well as the standard deviation of the results. The scale was kept numerical for further interval processing.

In order to show a comparative analysis of the results, we have reported the means, standard deviation, and performed *paired T-tests* on the two groups, designers and students, separately, to check whether either group (for MOT 1.0 and for MOT 2.0; or before and after adding the new *Social Layer*) scored *significantly* higher in total.

Analyzing the results, we can say that students showed a significant preference for keyword-based access of other author's content in social MOT 2.0, and an almost significant preference for browsing other author's domain maps and modules. The results for the designers show an (almost significant) increase in preference for keyword-based access, but none in browsing other author's domain maps. Looking for the reasons given in their qualitative feedback, at least two designers mention copyright as a concern in their reply to both questions. As MOT 2.0 allows a higher degree of sharing, the designers' answer to *browsing other author's modules* shows an increase of this concern. Clearly there is a difference in mentality between the Web 2.0 free-for-all concept and company-driven views related to ownership and profit. Such issues need to be solved in the future not only at the relatively small scale of an adaptive social authoring tool, but for Web 2.0 in general, in order to be used in commercial applications. In our system, we plan to solve this in two ways: One is to have a *private*, *group* and *public* label for created content. Private content will thus be only visible to the author, group to the author's group, and public to all. Moreover, we plan on allowing authors to tag their content with the exact copyright restrictions they aim at, so that even publicly available content has copyright information.

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[3] i.e., questions starting with 'what do you think of …?' instead of 'Do you like ..?' etc.

Other questions we asked concerned *browsing other author's lessons* (with a slight *Diff=0.1* difference in means for designers, and *Diff=0.66* for students) showing an almost significant (*p=0.08*) preference for MOT 2.0; adding *collaborative authoring* (i.e., tagging, rating, commenting) (with *Diff=0.5* for designers and *Diff=0.09* for students) showing thus a slight, non-significant preference for MOT 2.0. Here, evaluations on a larger scale can establish if these differences are significant.

When asked about *copying items across the author's own modules; linking to concepts from someone else's domain map(s); creating lessons based on someone else's; adding authoring for collaboration* (i.e. defining groups of authors, subscribing to other authors), preferences for MOT2.0 were shown by authors, but no significance could be established. From the designers' qualitative feedback, issues such as rights, of access, copyrights, etc. were raised and need to be integrated into the system, as explained previously. To some extent surprisingly, students showed identical average preference for both systems for this latter set of questions. A question like the one on authoring for collaboration was only of theoretical nature when asked whilst using MOT 1.0, but referred to implemented and usable functionality in MOT 2.0. So a simple explanation could be that the students' initial expectations were met in MOT 2.0. Moreover, analysing the students' data for these questions for which the average evaluation for MOT 1.0 and MOT 2.0 remained the same, we noticed that all these averages are equal or greater than 4. This means that these questions obtained already a higher mark for MOT 1.0, and there was not enough space left for improvements. To analyse this issue further and understand if students really thought the two systems faired alike for this set of questions, we looked at the qualitative students' comments. Here, when talking about collaboration techniques in MOT 2.0, a student writes "team based creation is very useful & not available in MOT 1.0". This shows a clear preference for MOT2.0, although the mark he gave for both was the same.

Nevertheless, more evaluations are necessary to establish if the social authoring system is an overall better paradigm. Moreover, from a learning perspective, evaluation of the learning outcome also needs to be targeted, to establish the overall performance of the merger between authoring and learning in MOT 2.0.

In the current paper we have focused on the evaluation of the authoring aspect only. As such, the initial results are promising and point to future development needs. The right combination of grouping and permissions need to be achieved. In the words of one of the designers: "It is useful that authors collaborate to create good content. In my opinion a good approach would be creating 'working groups' for developing modules. Every member of a working group should have full access to create, edit, tag, rate, comment, etc each item of the specified module. This way you know that the content is developed by known authors which form a developing team and collaborate to create the content. The team should be decided by a supervisor and should include teachers, developers, testers, etc (all roles involved in content development)."

These are the directions in which the further work on MOT 2.0 will continue, with the added benefit that these social interactions will be possible in the context of adaptation, and this adaptation will be available not only to learners, but also to designers and teachers, supporting them all the way, as exemplified in the initial experiments and in the screenshots shown in Figure 2.

6 Related Work

A significant research has been done in the area of modelling adaptive educational hypermedia systems, as mentioned above in section 2. However, none of the adaptive hypermedia reference models has modelled the social activities, which include collaborative authoring and social annotation.

Nonetheless, previous work has already been established to study the relation between adaptive educational hypermedia and the social web. For example, in [15] they study how to use a user tagging history to build adaptive user profiles; whereas in our approach, we use all users' social actions to update the user model; these actions include editing the content, tagging the content, rating the content and commenting on the content. Moreover, we use users' relations in updating their profiles; these relations include joining/leaving/creating a group, subscribing to other users, etc.

Other work focuses on personal recommendations based on the relatedness between the tags, as in [21]; in our approach, we currently use the same technique; however for future versions, we plan to apply other adaptive learning strategies as described by the LAG language. Furthermore, in [1] user groups are created based on the user tags; whereas in our method, we allow the end users to have full control on creating/joining/leaving the groups based on the user's privileges within the system.

7 Conclusion and Future Work

In this paper, we have presented the theoretical fundaments of combining the Social Web with adaptive educational hypermedia, by bringing together well-known reference models of Adaptive Educational Hypermedia, and comparing their features. In addition, we have defined a new layer in LAOS, the *Social Layer*, which has been exemplified by developing an adaptive e-learning 2.0 engine, MOT 2.0, based on the Social LAOS framework. The new Social Layer and the MOT 2.0 system have been evaluated and validated through a set of experiments, which confirmed, overall, that this merger is of value and interest and the new Social Layer is necessary in modelling of adaptive educational hypermedia systems.

Our main contributions are: 1) adding a new *Social Layer* in LAOS; 2) blending the authoring and learning phases; 3) allowing students to contribute in the authoring phase with different sets of privileges; 3) recognizing between *collaborative authoring* (i.e. editing the content of other users, describing the content using tags, rating the content, commenting on the content, etc); and *authoring for collaboration* (i.e., adding authors activities, such as defining groups of authors, subscribing to other authors, communications between authors, etc).

In the current implementation, for simplifying the experiment, we only based recommendations on similar tags between modules, as the focus was on the *added value of social interactions and grouping*. For future work we shall incorporate generic adaptation strategies into MOT 2.0, e.g., based on LAG [6]. In this way, interactions and adaptive behaviour can be specified independent on the content and/or the learners involved, and reuse of adaptive behaviour becomes possible.

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Semantic Evaluation Services for Web-Based Exercises*

George Goguadze

Faculty of Computer Science, University of Saarland
george@activemath.org

Abstract. ActiveMath is a Web-based intelligent learning environment for mathematics. One of the major components of ActiveMath is a subsystem for interactive exercises. In order to allow for intelligent diagnosis of learner's answer in an exercise step ActiveMath remotely connects to external mathematical reasoning services. This diagnosis is used for instant updating of the Learner Model of ActiveMath with the current mastery values of the learner w.r.t. the domain concepts he learns as well as it serves as a basis for providing adaptive feedback to the student. We describe the framework of semantic evaluation services of ActiveMath, and the generic format for queries to such evaluation services which are specifically oriented to facilitate diagnosis and feedback generation in interactive exercises.

Keywords: interactive exercises, semantic web services, intelligent diagnosis.

1 Introduction

There have been a few approaches to bring mathematical services into the web. Among the successful and useful ones is a web service architecture of MONET project [8], offering connection to different Computer Algebra Systems (CASs) as web-services serving arbitrary computational purposes. Another impressive example is a MathServe [11] framework for sharing logic-based reasoning services within a Mathematical Semantic Web.

Our goal in ActiveMath is to design a specific service architecture that serves the needs of interactive exercises. ActiveMath is a web-based learning environment for mathematics that incorporates an integrated collection of tools facilitating self-regulated as well as teacher-guided learning process [7]. We briefly sketch some major components of ActiveMath that are also described in, e.g. [6].

The central component is a `Course Generator` that uses information about learning objects, the learner and his/her learning goals to generate an adaptive sequence of learning objects that supports the learner in achieving his goals.

`Learner Model` is gathering information about learner and his progress and making estimations about current mastery of domain concepts.

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Search component is facilitating search and retrieval of knowledge from the mathematical database of ActiveMath using semantic search criteria, such as metadata search.

Finally, Exercise Subsystem is a major component of ActiveMath. It serves two fundamental purposes: assessment of the learners knowledge that informs the ActiveMath's Learner Model of the learners mastery of domain concepts that serves as a basis for further adaptivity; training the learner aiming to increase his mastery of the domain concepts.

This paper describes architecture for cross-domain mathematical query service, and a query format which is specific to educational purposes of interactive exercise framework. In order to determine which queries to the reasoning services are valueable for accurate diagnosis and adaptive feedback generation we use experience of several Intelligent Tutoring Systems alongside with results of research on cognitive psychology (see Narciss's conceptual framework for feedback in interactive instruction [9]). The novelty of this work is that the evaluation services are generic and cross-domain, and dedicated to exercise-specific reasoning.

2 Semantic Services in ActiveMath

For facilitating diagnosis of the learner's answer as well as generating informative and error related feedback, we have designed a specific query format and the set of queries we use to access remote mathematical services, such as CAS or more sophisticated domain reasoners capable of generating the solution paths of the problem or diagnose learners progress and typical errors.

The semantic OpenMath markup for mathematical formulas [10] used by ActiveMath and a generic format for queries to the semantic services described in the Section 3 support the interoperability of different CASs and reasoners when serving complex domains. For each service, the OpenMath formulas are translated to and from the syntax of the service via a dedicated translator program, called a phrasebook.

Currently, ActiveMath integrates and communicates with the following CASs: YACAS[1], Maxima[2], and WIRIS[3]; phrasebooks for Maple[4] and Mathematica[5] are available too.

Apart from CAS, some domain reasoner services are already available and some are being implemented.

Figure 5 shows different ways of connecting to external services that we realized in our framework. WIRIS CAS server is connected to ActiveMath via XML-RPC and contains an internal OpenMath phrasebook. The Maxima server communicates via WDSL and the queries are piped through an external phrasebook. Connection to WIRIS CAS and Maxima, as well as phrasebooks for

[1] see http://yacas.sourceforge.net

[2] see http://maxima.sourceforge.net

[3] see http://www.wiris.com

[4] see http://www.maplesoft.com

[5] see http://www.wolfram.com

Maple and Mathematica was implemented within EU-project LeActiveMath[6]. The YACAS server that was developed in ActiveMath group has native support for OpenMath and is communicating directly via an internal OpenMath protocol.

Domain Reasoners SLOPERT and MathCoach are implemented as prolog programs running with SWI prolog[7] embedded into wrapper servers written in java to which ActiveMath can connect via XML-RPC protocol. MathCoach server is a good example of a service that is running entirely independently from ActiveMath and even receiving queries from clients other than ActiveMath[8].

2.1 Diagnosis and Feedback Using CAS

CASs were the first type of systems ActiveMath connected to for facilitating interactive exercising (see [2]).

CASs are very efficient and fast in providing diagnoses needed for the generation of a flag feedback (correct/incorrect) as well as for the final correct solution for the given problem.

But for interactive exercises with multiple steps CAS diagnosis proved to be too shallow, and sometimes even allowing the learner to cheat. Thus, when comparing the learner's answer to the correct solution, CAS would accept learner's answers as correct even if he just repeats the problem statement. Therefore, some more sensitivity w.r.t. the mathematical context was needed. The first attempt to correct this situation in ActiveMath was introducing three basic contexts for evaluation of learners input: syntactic - meaning literal comparison to the

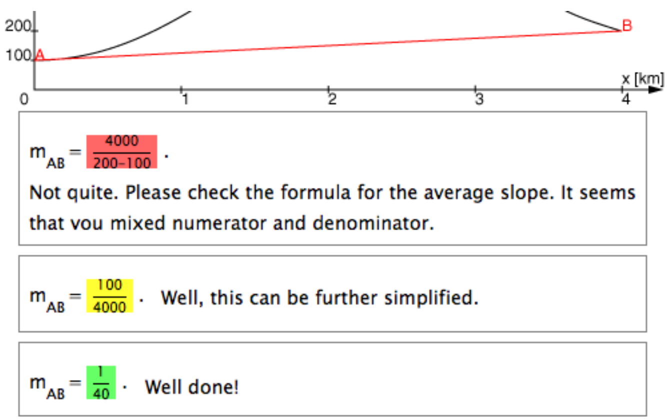

Fig. 1. Different kinds of a basic diagnosis

6 see http://www.leactivemath.org
7 see http://www.swi-prolog.org
8 see http://mathcoach.htw-saarland.de

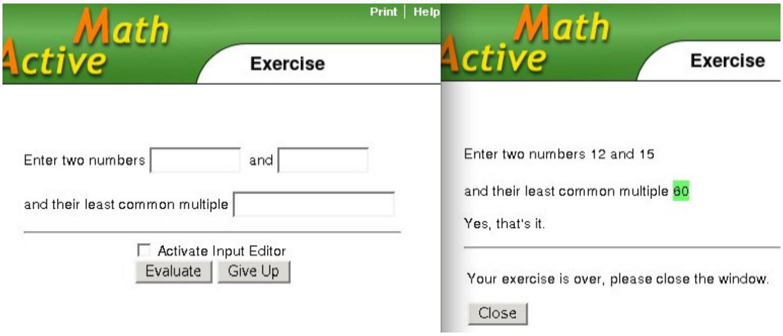

Fig. 2. Vector evaluation example

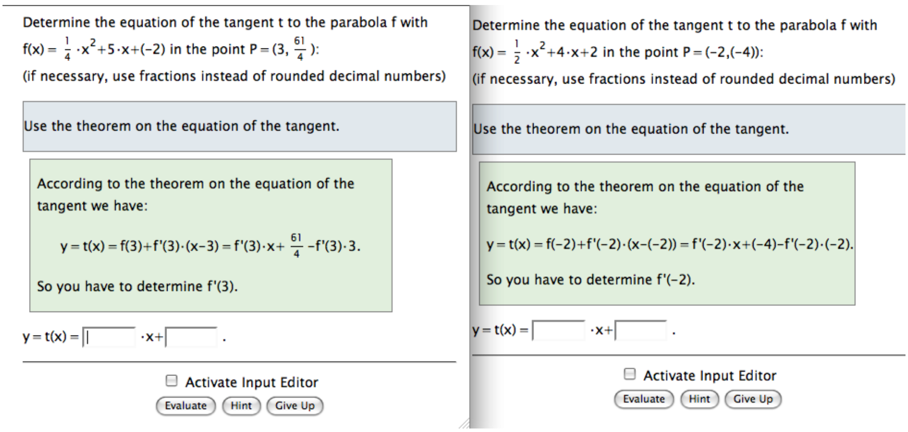

Fig. 3. Different instances of a randomized exercise

correct result, numeric - representing numeric comparison with some epsilon, and semantic comparison using CAS. Figure 1 shows different kinds of diagnosis possible using these three basic contexts.

Another example, shown in the Figure 2 illustrates the possibility of defining complex constraints upon the learner's input in a so-called vector-evaluation.

CAS services are also used for creating so-called randomized exercises, in which the complete solution of an interactive exercise is parametrized. For every admissible instantiation of the parameters a concrete exercise and its solution can be generated. The Randomizer of the exercise subsystem of ActiveMath generates exercises by instantiating the parameters with randomly chosen values from defined ranges over numbers and intervals, but also any set of mathematical functions and their superpositions, as described in [3].

Since the solution of each step of a problem is represented as a mathematical expression, for each randomized exercise answers/input from the student can be diagnosed as correct or incorrect by a CAS. An example of different instances of the same randomized exercise are shown in the Figure 3.

2.2 Stepwise Analysis with Domain Reasoner

More detailed diagnoses can be obtained when a domain reasoner is available for the mathematical domain of the exercise. A domain reasoner can send responses to queries which are used to generate common types of hints for the learner such as

- next step hint
- correct solution for current step
- number of steps to final solution, etc.

An example of a domain reasoner service is SLOPERT [12], which encapsulates expert and buggy human-like rules for the (mathematical) domain of symbolic differentiation. This service maintains an internal state and, thus, can trace the (partial) solution of the student and diagnose his/her errors.

Another domain reasoner, currently connected to ActiveMath is MathCoach [4], which is stateless and cannot trace student's solution. This domain reasoner does not identify typical errors of the student, but it is able to solve the given problem incrementally. Already using this information, ActiveMath is able to generate sequenced informative feedback, as shown in the Figure 4.

Firstly, ActiveMath queries domain reasoner for the next rule to be applied and the domain reasoner automatically detects the name of the expert rule to be applied. As the first hint, ActiveMath just tells the learner to apply this rule. Based on this information, ActiveMath can generate a further conceptual hint in which it extracts the definition of the rule automatically from the knowledge base and presents it to the learner. Automatic retrieval of the meaning of the

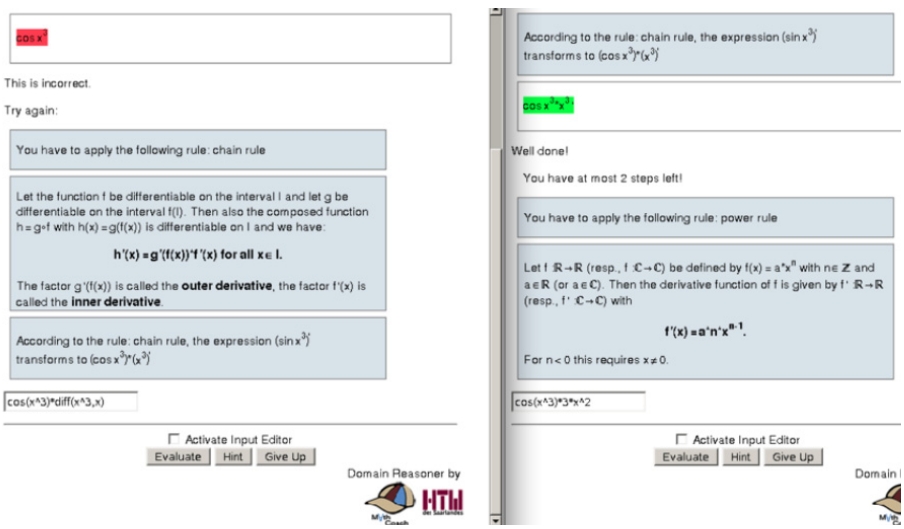

Fig. 4. Domain reasoner powered feedbck generation

rule in ActiveMath is possible due to the fact that ActiveMath receives semantic representation of this rule in OpenMath. Finally, the bottom-up hint for the current step can be also generated by the domain reasoner in which it applies the needed rule to the current task.

3 Generic Query Format

In ActiveMath generic queries are used to access any diagnosis service. The queries include a number of dimensions, one of them is *context*.

A context defines (sub-)sets of rules and functions that a domain reasoner or a CAS is allowed to use for its diagnosis. The background for this restriction is that the student's learning situation determines which 'rules' and functions he/she is capable to employ. Hence, the diagnosis need to simulate this rather than accepting a student input saying 'solve'.

Consider the following example: The task of the student is to differentiate a function $f(x) = (x + 1) \cdot x$. If the student has not yet learned the product rule, a reasonable and correct next step would be an arithmetic transformation that removes brackets. Using the product rule would not be expected from the student. In this case, the evaluation of the student's answer needs to exclude the product rule from the context but include the arithmetic context.

In order to formalize queries used for diagnosis and feedback generation we defined the format for queries in which a query to the domain reasoner service consist of:

- **action** of the query, e.g. `getResults`, `getUserSolutionPaths`
- **(list of) input expressions** to be evaluated or compared with each other, e.g., evaluating or simplifying task, comparing a user answer with correct answer
- **context** of action identifying the set of applicable rules, e.g., arithmetic, differentiation, logic
- **number** of iterations defines how many atomic steps the domain reasoner should perform in the given context.

In the following, e, e_1, e_2, are OpenMath expressions, C is a context of a query, N is the number of iterations. A solution path is a list of results of consecutive rule applications, which are annotated with rule identifiers.

Currently the following queries to diagnostic services are used in ActiveMath:

- query(`getResults`, e, C, N) - returns the list of final nodes of all paths of length N starting at e in the context C
- query(`compare`, e_1,e_2, C, N) - returns true if there exists a path of the length N from e_1 to e_2 in the context C, false otherwise
- query(`getRules`, e, C) - returns the list of the identifiers of expert rules applicable to e in context C

– query(`getBuggyRules`, e_1, e_2, C, N) - returns the list of the identifiers of all buggy rules that belong to a path from e_1 to e_2 in the context C. This query is possible for those domain reasoners that can reason with (typical) buggy rules and some CASs, which can be extended to do so.
– query(`getUserSolutionPaths`, e_1, e_2, C, N) - returns the list of all paths of length N from e_1 to e_2 in the context C
– query(`getExpertSolutionPaths`, e, C, N) - returns the list of all paths of length N starting at e in the context C. In this query C can consist of expert rules only.
– query(`getNumberOfStepsLeft`, e, C) - returns the number of steps left to reach the final node of the shortest expert solution path in context C
– query(`getRelevance`, e_1, e_2, C) - returns 'true' if the expression e_2 is closer than e_1 to the actual solution in the context C,

Several simple contexts can form a composite context by concatenating sets of their rules. Consider a following example query to a domain reasoner:

Example query: *Calculate the next two steps for computing derivative of the function* $f(x) = (x+1)\cdot x$ *using only arithmetic simplifications and differentiation rules except for a product rule.*

Using our query format we can formalize the example query as follows:

$$\text{query}(\texttt{getResults}, (x+1)\cdot x, C, 2),$$

where C is the composite context consisting of arithmetical context and differential rules without product rule.

4 Query Broker Architecture

ActiveMath implements a service architecture for querying remote mathematical services for the special purpose of the diagnosis of student's actions in mathematical problem solving and incrementally expanding the solution of the given problem. These tasks imposes some requirements upon such services, such as modularity, interoperability and controllable depth of iterations. These requirements are partially reflected in the defined query format.

A broker architecture distributes queries to external diagnosis *services*, as shown in Figure 5.

The `Query Broker` accesses those services that are registered for the (mathematical) context of the current query. For instance, a domain reasoner for symbolic differentiation is only queried for problems in symbolic differentiation. The subscribed mathematical services themselves can also send a query back to the `Query Broker`. For example, a domain reasoner for symbolic differentiation can send a query back to the broker if it needs to simplify an arithmetic expression. The `Query Broker` passes this new query to a CAS or arithmetic domain reasoner. There are no restrictions upon the technology used for implementation of the external reasoning components, as well as no requirement for the service to be stateful or stateless.

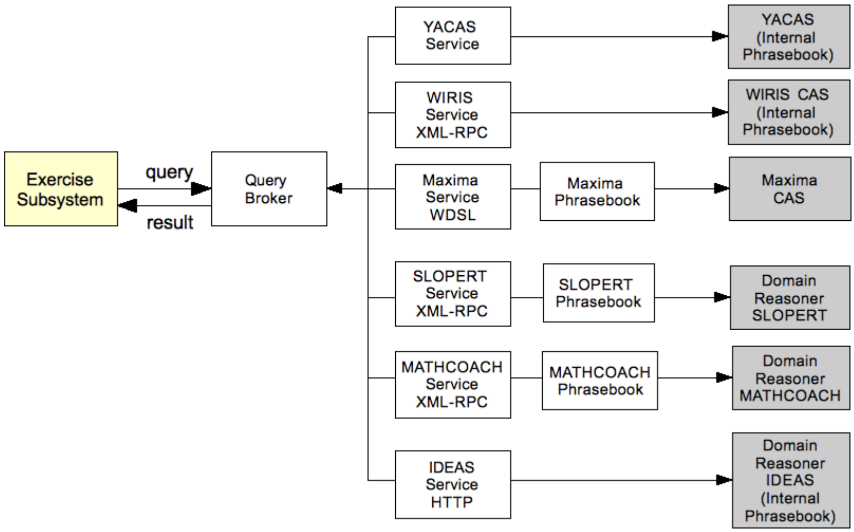

Fig. 5. Diagnosis framework architecture

5 Work in Progress and Future Work

One of the ongoing efforts is a generic solution for automatic composition of connected services in order to reach cross-domain reasoning. That is, the complex query that involves more than one context needs to be managed by the `Query Broker`.

Also, more domain reasoners are being connected to ActiveMath. The current target is the series of domain reasoners implemented within an 'Intelligent Feedback Project' at the Open Universiteit Nederland [5]. Several domain reasoners have been programmed using programming language Haskell[9] and offered as reasoning web services answering queries similar to one we define in ActiveMath (see section 3). Among areas/tasks covered by these domain reasoners are, e.g. rewriting logical expressions into disjunctive normal form, solving linear equations, reducing matrices to echelon normal form, and basic operations on fractions. These services offer incremental reasoning, also checking for syntactical errors as well as matching common semantic errors using buggy rules.

Another effort is to turn generic rule engine of YACAS computer algebra system, into a multi-domain reasoner. This is possible since YACAS is rule-based, highly modular and easily extensible. New domains can be attached to YACAS by exchanging or extending the current domains that are represented as modules in form of scripts that can be attached as parameters to the YACAS process or loaded into the running system on fly.

Ongoing work is implementing rule based domain reasoners in the form of YACAS modules, that could provide more sophisticated stepwise diagnosis and

[9] see http://www.haskell.org/

are answering ActiveMath specific queries. For each of the modules, several special functions are being implemented that answer the queries defined in the Section 3.

Last but not least, several classroom and lab evaluations of ActiveMath exercise system and its diagnostic capabilities are ongoing within two German research projects ATuF (Adaptive Tutorial Feedback) and ALOE (Adaptive Learning with Erroneous Examples). These projects aim to research learning effects of several adaptive feedback strategies for interactive exercises, where adaptation and feedback generation highly relies upon correct diagnosis of learner's actions.

6 Conclusion

ActiveMath has all the typical components of an intelligent tutoring system (ITS) such as a `Learner Model`, and pedagogical model/modules including `Course Generator`, expert/domain model represented by content ontology and formal domain reasoners connected to the system.

Therefore, we bring ITS system's functionality into a web-based environment and open horizons for many features of web-applications including accessibility of multiple reasoning services, and offering our own system as a web-service, not talking about many other features of a Semantic Web application that ActiveMath possesses (see, e.g. [6]. That makes ActiveMath a workbench for studying benefits of combining ITS and semantic e-learning technologies as suggested in [1].

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Applying a Web and Simulation-Based System for Adaptive Competence Assessment of Spinal Anaesthesia

Cord Hockemeyer[1], Alexander Nussbaumer[1], Erik Lövquist[2], Annette Aboulafia[2], Dorothy Breen[3], George Shorten[3], and Dietrich Albert[1]

[1] Department of Psychology, University of Graz, Austria
{cord.hockemeyer,alexander.nussbaumer, dietrich.albert}@uni-graz.at
[2] Interaction Design Centre, University of Limerick, Ireland
{erik.lovquist,annette.aboulafia}@ul.ie
[3] Health Services Executive South, Cork University Hospital, Ireland
dorothybreen@financialcontroller.ie, george.shorten@hse.ie

Abstract. The authors present an approach for implementing a system for the assessment of medical competences using a haptic simulation device. Based on Competence based Knowledge Space Theory (CbKST), information on the learners' competences is gathered from different sources (test questions, data from the simulator, and supervising experts' assessments).

The envisaged architecture consists of three core modules, an LMS (Moodle) containing user model and content objects and realising the interface between system and user, a simulator interface as an own service connecting the LMS to the (external) simulator system, and a CbKST service offering the assessment logic and visualisations of the assessment result for learner and teacher.

Keywords: Adaptive Competence Assessment, Medical Training, Haptics, Simulation, Moodle, Competence-based Knowledge Space Theory, Spinal Anaesthesia.

1 Introduction

Medical training has been undergoing major changes worldwide, recently. Reasons for this include new employment legislation as well as changing patient expectations, increasing awareness for quality assurance needs, and liability jurisdiction. As a result, it is becoming less acceptable that doctors in-training practice their procedural skills on patients. One solution to this is the application of advanced computer technology (e.g., Virtual Reality or haptic devices) for simulating medical procedures during the early practical training.

This paper describes the MedCAP [http://www.medcap.eu/] approach to integrate a haptic device and a psychological model of knowledge and competences with a state of the art learning management system. Within this aim, we focus on the technical realisation of previously published conceptual ideas [1, 2].

After briefly introducing spinal anaesthesia and the Competence-based Knowledge Space Theory (CbKST) in the remainder of this introduction, we will give some

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general information on the web and simulation based system for spinal anaesthesia. In Section 3, we describe the adaption of CbKST's competence assessment procedure to the medical domain, and in Section 4 the architecture of the resulting system.

1.1 Procedure of Spinal Anaesthesia

Spinal anaesthesia involves injecting a small amount of local anaesthetic through a needle inserted between the spinal vertebrae, below the end of the spinal cord into the surrounding spinal fluid (Figure 1). The local anaesthetic quickly blocks the patient's sensations below the point of injection providing excellent operating conditions for surgery on the lower part of the abdomen and legs.

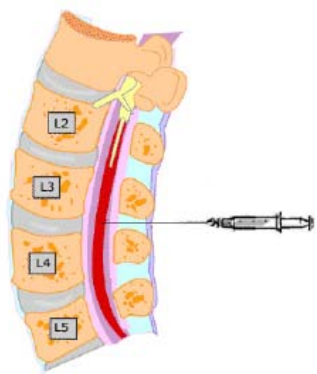

Fig. 1. Demonstration of a spinal anaesthetic injection

Almost always, the procedural skill of spinal anaesthesia is learned by watching a more experienced practitioner and subsequently performing the procedure on a patient under close supervision. Clearly this process has disadvantages. The patient can be put at risk by having a potentially hazardous procedure performed by a trainee. The training opportunities are limited by the type and number of patients who are suitable for the procedure of spinal anaesthesia during the time of the training.

1.2 Competence Based Knowledge Space Theory

Doignon and Falmagne [3, 4] developed the theory of knowledge spaces originally as a behaviouristic approach to adaptive assessment of knowledge. The core idea is to describe a domain of knowledge by a set of test items, and to structure this set of test items by prerequisite relationships. They identify a learner's knowledge state as the subset of test items this learner is able to solve. The set of possible knowledge states – the *knowledge space* – is strongly constrained by the prerequisite relationships. The knowledge space also delineates reasonable learning paths, i.e. ways to sequence the items to learn such that the learner has all the prerequisites for the current item.

The prerequisite relationships can be visualised as a Hasse diagram. Figure 2 (left side) shows a hypothetical Hasse diagram for a set of five items (*a* to *e*) where, e.g., *a* is a prerequisite of *b*, and *b* and *c* are both prerequisites of *e*. As a consequence, *a* also

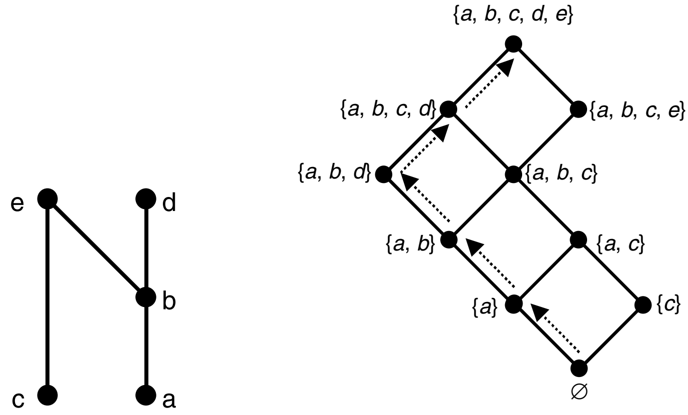

Fig. 2. Hasse diagrams of a hypothetical prerequisite relation and the corresponding knowledge space. The dashed arrows denote one possible learning pat within that space.

is a prerequisite of *e*. The right side of Fig. 2 shows the corresponding knowledge space (again as a Hasse diagram) and one possible learning path through this space.

Albert and his research groups have focused on investigating the underlying cognitive structures (see, e.g., [5]) resulting in the development of Competence-based Knowledge Space Theory (CbKST) [6]. The basic idea here is to assume the existence of unobservable competences underlying the observed problem solving behaviour. These competences are again structured by prerequisite relationships.

The adaptive assessment of knowledge is a core element of knowledge space theory [7, 8, 9]. Ideally, the assessment procedure should start with a test item of medium difficulty and then, depending on the learner's answer, continuing with either easier or more challenging test items. Knowledge space theory allows us to ground this not only on some rather abstract measure of difficulty but on the concrete prerequisites between the individual test items (or competences, respectively).

Looking at the hypothetical knowledge space in Fig. 2, a teacher might start an assessment by asking item *b*. If the learner gives a correct solution, there is no need to test item *a*. In case of a wrong answer, however, there would be no need to test items *d* and *e*. On average, the teacher would have to ask 3.3 items in order to know for all five items whether the learner can solve them or not. For larger item sets, the savings are usually larger.

Practically, the assessment works, of course, non-deterministic. The assessment procedure maintains a likelihood distribution over the knowledge (or competence) space. After each evidence, the likelihood distribution is updated using a generalised form of Bayes' theorem, i.e. the likelihood of states fitting to the last evidence is increased and the likelihood of states not fitting to the last evidence is decreased. The deterministic variant described in the previous paragraph is effectively a special case of the likelihood update where the probabilities for careless errors and lucky guesses are 0 [8]. Simulation studies have shown that the loss of efficiency (in the sense of the number of items to be asked) by moving from the deterministic to the probabilistic procedure is very small [9].

2 A Web and Simulation-Based System for Spinal Anaesthesia

The assessment procedure consists of two separate systems for gathering information from the assessed anaesthetist. These two systems are interlinked to create a natural flow of the assessment procedure.

2.1 The Web-Based System

The assessment procedure utilises a problem-based learning approach, where scenarios of patients are presented in an electronic format in the open-source learning management system Moodle (moodle.org/). The patient scenarios is written by experienced anaesthetists. Each scenario consists of information and questions, which the assessed anaesthetist has to go through as a part of the assessment procedure. The scenarios consist of an extensive amount of film clips and pictures, enhancing the information given in each case. All of the media was taken in the clinical environment by participating anaesthetists.

2.2 The Haptic Simulator

The simulator uses haptic technology, which enables the user to interact with and feel objects in virtual environments [10]. The spinal haptic devise simulates the needle insertion aspects of performing spinal anaesthesia and generates realistic sensations and visual representations of actual patients [11]. It utilises a Phantom Desktop [www.sensable.com] and is implemented in the haptic environments H3D API [www.h3d.org] and Volume Haptics ToolKit (VHTK) [12].

The haptic device allows tracking the user's movements in real time, providing the functionality of incorporating metrics for automatic assessment of performance on the virtual patient. Textures and 3D models representative of the patients in the cases are incorporated in the simulator, see Fig 3.

The simulator assessment is directly linked to the question interrogation, i.e. at a certain stage of a scenario the anaesthetist has to perform the procedure on anatomy corresponding to the patient of that specific case.

Fig. 3. To the left is a picture of the haptic device in use in the virtual environment and to the right, a screen capture of a patient's back

3 Medical Competence Assessment

3.1 Adaptive Competence Assessment

Assessment procedures on "classical" knowledge spaces (i.e. in the original behaviouristic approach by Doignon and Falmagne) have been well investigated (see, e.g., [7, 8]). The most common approach models a likelihood distribution over the complete knowledge space. Test problems are selected for which the likelihood estimate of being mastered is close to 0.5, i.e. for which the system has yet little knowledge about their mastery. Depending on the learner's answer, the likelihood estimate is updated applying a generalised version of Bayes' theorem. Simulations have shown that this procedure is very close to have a complete assessment result with minimal effort, i.e. number of test problems posed to the learner [9].

Compared to assessment in classical knowledge space theory, the assessment of competences in CbKST is a rather new area of research and development. A first, straightforward approach was taken by Heller et al. [6] who suggested to do a classical assessment on the level of test items and, afterwards, to map the resulting knowledge state to its corresponding competence state. The more recent approach of *microadaptivity* [13] includes changing the order of these steps, i.e. to interpret the observed responses to the individual test item with respect to the underlying competences and to perform the assessment procedure on the competence space.

More concretely, the part of microadaptivity used here is an assignment of tested competences to each test item. Solving or failing such an item is then interpreted as positive or negative, respectively, evidence on mastering the assigned competences.

3.2 Different Modalities of Information Gathering

In the context of medical assessment to be performed as a mixture of examination questions, simulator work, and supervised work with patients, this combination of different modalities provide a special challenge. A computer based system for medical competence assessment has to be able to deal with all these different sources of information on the candidate's competences.

1. The classical source is test items to be posed to the candidate. As described in Section 3.1 above, the candidate's answers are interpreted as evidence on having or not having the competences assigned to the respective test item.
2. A first new source refers to classical ways of teaching by supervised practising. Instead of posing questions to the candidates, an expert supervises their work on the simulator or on a patient. Afterwards, the expert answers a questionnaire with respect to the candidate's competences.
3. A second new source is given by the simulator itself. In a first step, certain metrics will be transferred from the simulator to the learning management system after finishing the simulation. These metrics will then be interpreted with respect to the learner's competences. A more advanced usage of the simulator will be the aim of future research projects.

This leads, of course, to changes in the assessment procedure. Especially, the selection of test problems has to be changed. The selection of test problems which promise to uncover maximal information on the candiadate's copetences is replaced by a whole set of quasi-problems given at once. While such a block of information may contain some redundancy, they will nevertheless completely be used.

Furthermore, since testing in medicine frequently follows the storyline of case scenarios, even in the case of test items to be posed to the candidate, there can be no arbitrary choice. Many of these test items contain information about the case that is needed in the later course of the scenario. Therefore, instead of selecting the test item that maximises the gain of assessment information the system can only decide whether the next item is likely to give new assessment information or whether it could be replaced by some message simply telling the medical data contained in the item.

4 An Integrating System Architecture

The overall system consists of three main components which are the Web application, the Simulator (together with the simulator interface), and the CbKST service. (Two groups of users (actors) are working on the system, the supervisors/experts and the candidates. Furthermore, domain model and user model needed for the competence assessment logic are stored and managed in the CbKST Web service. However, domain and user model contain only referential information, the actual problems (assessment items) and user information are stored in the Web application. This design of separating Web application from assessment logic follows the approach described in [14] and [15]. An illustration of this architecture is shown in Fig. 4.

The Web application guides the candidate through the several scenarios and respective problems, which are stored and managed by this Web application. It also contacts the CbKST Web Service for each problem if it should be posed or not and it reports back about the correctness of the user's answers (first assessment source). Moreover it initiates the work on the simulator by contacting the simulator interface and by telling the user to switch to the simulator. Also the expert supervising the candidate uses the Web application to fill out the questionnaire which is also transmitted to the CbKST Web Service in order to be used for the assessment calculation (second assessment source). The result of the competence assessment procedure is presented to the candidate in a simple form by showing a list of available and non-available skills. For a more detailed graphical visualisation of the assessment result, the Web application makes available the respective applet as part of the CbKST Web Service by providing the link which opens this visualisation component.

The simulator allows the user's actions to be constantly tracked when performing the procedure on the virtual anatomy (third source of assessment information through the simulator interface described below). The metrics are used as the measurements of how the user is performing. Each metric can be seen as an assessment item which tests a set of skills.

The simulator interface is the software component which connects the physical simulator to the Web application and the CbKST service. It initiates and controls the practice on the simulator and it reports the results of this practice to the CbKST service.

The CbKST service is responsible for the logic of the competence assessment. It exposes an interface as Web Service which can be contacted by the Web application and the simulator interface for two purposes, (i) to report correctness of assessment items and practice on the simulator and (ii) to get the total result of the assessment in terms of available skills. This service has implemented the algorithms for competence assessment as described in Section 3, whereby the calculations are based on CbKST assessment procedures as described in Section 1.2. However, in contrast to the traditional algorithms, not the optimal problem is chosen to minimise the number to question, but the sequence of problems is controlled by the Web application. However updating the probabilistic values of possible knowledge states is done in the traditional way. Deriving the competence state is conducted by investigating the assigned skills of questions and metrics which a learner could solve. A domain model is used which contains information about problems and metrics, skills, skill assignment to problems, and prerequisites between skills. Furthermore, the CbKST service has available a user model containing information which problems a learner has already solved and which skills are available. Domain and user model information are stored in a database on the machine of the CbKST service.

In addition to the Web Service the CbKST service also has available a visualisation component which provides the learner with a graphical illustration of the assessment results. Following the approach described in [16], the learner gets a skill map (prerequisite relations between skills) in a visual form where the result is depicted. In this way the learner can see his or her competence state in relation to the knowledge domain. This method is supposed to initiate reflection and motivation of the learner. An illustration of this architecture is shown in Fig. 4.

The Web application is based on the popular Moodle learning management system (LMS) which is implemented in PHP and which runs inside of an Apache Web Server together with a MySQL database. The assessment procedure has been implemented as an extension of Moodle. Connection to the CbKST service is performed by using the nusoap PHP library (see http://sourceforge.net/projects/nusoap/). The simulator interface is implemented in Python, which is controlled by the simulation to send appropriate information to the CbKST service. The CbKST service is realised in an Apache Tomcat servlet container in order to provide visualisation component and Web service. The visualisation component is developed in Java and is made available as Applet. The Web service is exposed in an Apache Axis2 environment which is installed in the Apache Tomcat engine. The database for domain and user model data is located within the CbKST service. Web application and CbKST service are located on servers accessible over the Internet. The simulator requires a dedicated workstation connected to the Internet for accessing the web application. However, if a haptic workstation is not available, a simplified version of the assessment procedure using only the web application can be run on any machine with Internet access.

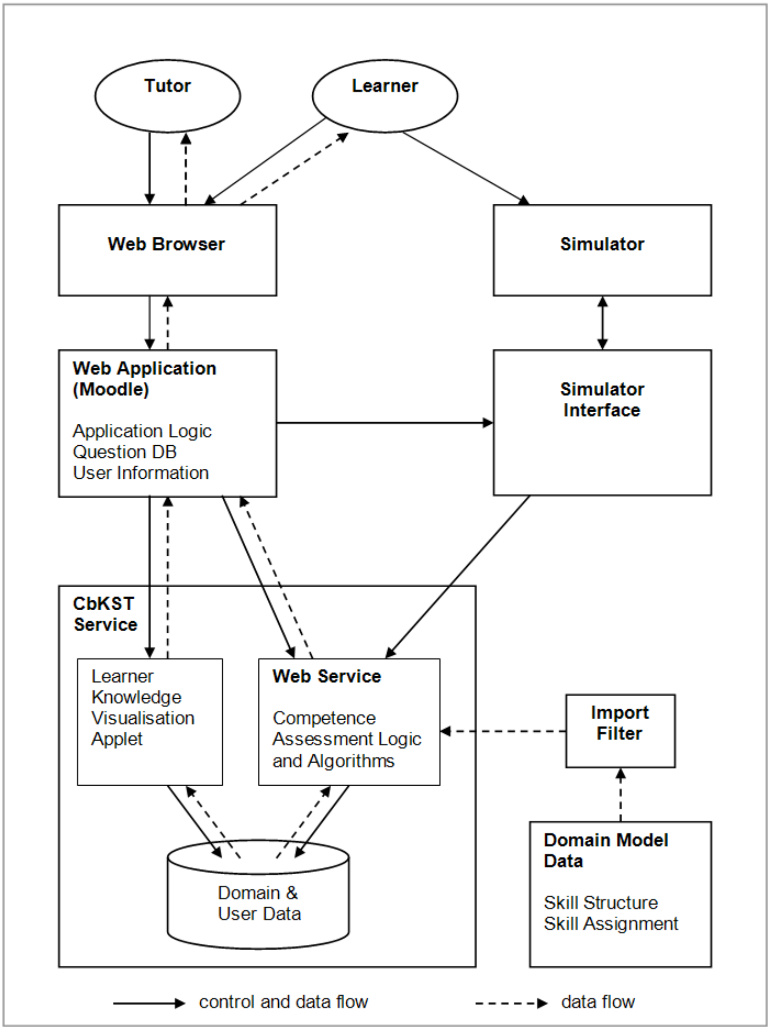

Fig. 4. In this figure, the overall system architecture is illustrated containing the main components of the system and their interconnections as well as the users (actors) operating on the system

5 Conclusions

We have described a novel approach to competence assessment for medical trainees. A multi-disciplinary co-operation of physicians, psychologists, and computer scientists has been leading to an assessment system which offers several important accomplishments. The inclusion of a haptic simulator device allows, one the one hand, to assess the trainees' procedural and haptic abilities without endangering patients health. On the other side, it is also a solution for restrictions by new working time regulations as well as restrictions imposed by the rare occurrence of special, complicated cases. Furthermore, results of the research and development described herein can serve as a basis towards an objective and standardized competence assessment for young doctors.

Still, there remains much work to do. One important issue is to go beyond pure testing and to extend the system in order to allow support also for teaching. A second issue is to extend the contents of the system in order to comprise the whole field of spinal anaesthesia.

Besides that, there is also the issue of computational efficiency. The medical domain of spinal anaesthesia seems to be less structured than other fields (e.g., mathematics or physics) resulting in high computational demands [17]. There are already theoretical developments on decreasing the computational demands during competence assessment, however [18], some further research is needed in this area.

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Developing the 3D Adventure Game-Based Assessment System with Wii Remote Interaction

Kuang-Min Huang[1], Jui-Hung Chen[1], Chun-Yi Shen[2], Louis R. Chao[1], and Timothy K. Shih[3]

[1] Department of Computer Science and Information Engineering, Tamkang University, Taipei, Taiwan, R.O.C.
kmhuang1985@gmail.com
[2] Department of Educational Technology, Tamkang University, Taipei, Taiwan, R.O.C.
cshen@mail.tku.edu.tw
[3] Department of Computer Science, National Taipei University of Education, Taipei, Taiwan, R.O.C.
timothykshih@gmail.com

Abstract. The advanced 3D graphic and computer technologies could provide advanced 3D virtual environment in order to let users have the immersion experiences in that environment. Also, as human interaction technologies, it could be helpful for providing more different and suitable interaction styles when facing some particula0072 interaction situations. The related works pointed out that the game elements could improve learners' motivation during learning. In this paper, we proposed the 3D Adventure Game-Based Assessment System could not only attract learners to take their assessment activities, but also help instructors to design and manage the related assessment content easily.

Keywords: 3D virtual environment, GBL, Wii remote, Game interaction.

1 Introduction

Games would not only provide the attractive game playing environment, but also imply the learning curve. Many researchers were interested in such issues. They pointed out that if we could combine the game play learning models with the formal learning models to develop the game-based learning content, it would be helpful in improving learner's learning abilities and efficiency [1][2], especially in 3D game environment. It could easily promote gamers' game playing motivation. The newly game –-based interactions developed by Nintendo Co. provide more humanized interaction control models for gamers to enhance their game playing motivation. Brian Peek developed the managed library for Nintendo's Wiimote in 2007 [3]. This is an API for Wiimote. It makes direct connection between Wiimote and PC as possible by Bluetooth protocol. Brain Peek proposed two API vision for C# and VB in order to let programmer to design the related application with Wiimote. Shinichiro Toyoda created a musical environment by combining with Wii Remote [4]. The application called "Sensillum". It contains an interface similar to painting software, and acoustic operation and musical composition is conducted by gesture using the Wii Remote. It

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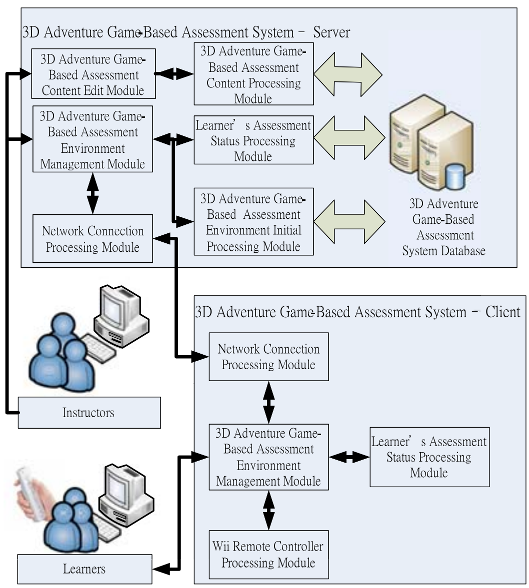
regards gestures as parameters to operate the musical instructions, and provides an interesting way to play music. And we could found that a lot of games in Wii platform will embed the learning content which could attract people on doing learning English characters, mathematic, calculating skill and so on. According to above discussions, it will provide the hint for us in developing the 3D Adventure Game-Based Assessment System which integrated with Wii remote interaction control models in order to build more easy and efficient knowledge learning and training environment. The remainder of this paper is organized as follows. In Section 2, we will illustrate our system architecture, related system modules, workflow and the sample demo of the 3D Adventure Game-Based Assessment System. Finally, the conclusion and the future work are shown in Section 3.

2 3D Adventure Game-Based Assessment System Architecture

In this section, we will introduce our proposed system modules and game playing workflow.

2.1 3D Adventure Game-Based Assessment System Modules

Fig.1. shows the modules of the 3D Adventure Game-Based Assessment System. In Server side, the Network Connection Processing Module is taking charge of the data



WiiRemoteMotion	θ
↘ (Put Down)	< -30
↗ (Put Up)	>30°
	< -45°
	>45°
Player's Vision	**Action**
Move Forward	CurrentX +=0.15*sin(look); CurrentZ -=0.15*cos(look);
Move Backward	CurrentX +=0.15*sin(look); CurrentZ +=0.15*cos(look);
Look left side	Look--
Look right side	Look++

Fig. 1. Modules of 3D Adventure Game-Based Assessment System & Wii Remote Control Pattern Definition

connection from backend server to user client. The assessment content edit module will be responsible for providing the adaptive content editing interface and related guilder to instructors in order to reduce the loading in doing content editing. The assessment content processing module will take charge of the data format checking and compressing. All data will be integrated in one zip package. The assessment content edit module will take charge of managing the related assessment materials, initial parameters and whole game assessment rules definition in 3D adventure game map. The assessment environment management module will take charge of managing require which provide by learner/instructor client. Like the user authorization, assessment content searching and assessment result managing. The assessment environment initial processing module will be responsible for game runtime management and data processing in backend server. The assessment status processing module will be responsible for the learners' assessment result processing and management in server side. In client side, the network connection processing module will take charge of the data connection from backend server to user client. The assessment environment management module will take charge of game playing runtime management, data processing and game status analysis in client side. The assessment status processing module will be responsible for the learners' assessment result processing and management in client side. The controller processing module will be responsible for providing the Wii remote interaction control patterns for learners to do their game playing behavior. Wii remote was made by Nintendo Co. and it integrated the acceleration sensor, IR sensor, Bluetooth technologies and traditional joystick functionalities. In Wii remote interaction behavior 3D move motion, we have defined the related move motion pattern and related processing algorithm which also shows in Fig.1. We utilized the definition parameter "Look" to handle the learners' view point when they doing the changing and moving motion behavior. The learner's position parameters "CurrentX" and "CurrentZ" will present as X Coordination and Y Coordination. We utilize the both parameters to control the learner goes forward/back in one step.

2.2 3D Adventure Game-Based Assessment System Workflow

Fig. 2 shows the 3D Adventure Game-Based Assessment System screen shot. The instructor could utilize the course authoring tool easily to make the assessment content by editing game missions in game map. Then the instructor sends the content to the backend server. At last, the learner could download it by using the assessment runtime environment. When the learner login to the system, the backend server will load the learner's assessment portfolio and try to initial the related game playing status. Then he/she could select the related assessment mission which he/she wants to get start. When he/she gets start and tries to solve the assessment mission, he/she could go to the related mission area in adventure map area according to get the hint information which provide by NPC (Non-Player Character) or related hint items. Then he/she could finish the game mission as quickly as possible. All the interactions in game could only make control by Wii remote. When he/she finish all missions, the game system will show the assessment status to the learner, save them into the individual learning portfolio and try to send it back to the backend server. Finally, the system will terminate.

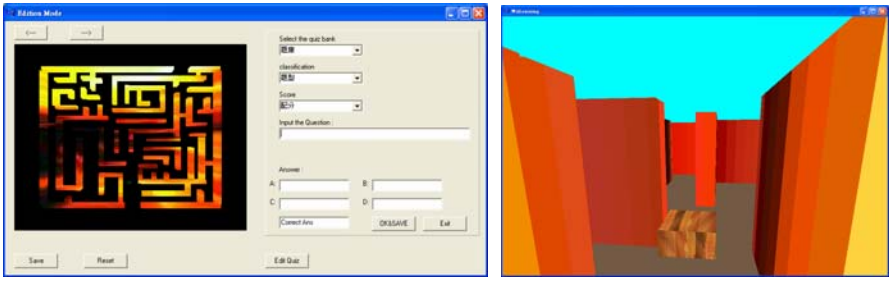


Fig. 2. 3D Adventure Game-Based Assessment System – Game Playing Environment Demo

3 Conclusion

In this paper, we proposed the 3D Adventure Game-Based Assessment System and related authoring tools. It could is not only reduce instructors' loading when editing the related assessment materials, but also improve learners' motivation in doing assessment activities. In addition, we provide the different interaction behavior which made by Wii remote interaction patterns in order to attract learners to have their immersive experiences in game-based assessment activities. In the next step, we will keep continue on expending the functionalities and try to involve the IRT (Item Response Theory) in our proposed system. We hope the system could help them enjoy their game-based assessment activities.

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Efficient Authoring of SCORM Courseware Adapted to User Learning Style: The Case of ProPer SAT

Ioannis Kazanidis and Maya Satratzemi

Department of Applied Informatics, University of Macedonia, 54006, Thessaloniki, Greece
{kazanidis,maya}@uom.gr

Abstract. Online courses are the most popular way to deliver knowledge for distance learning. New researches attempt to personalize the educational process with the use of the Adaptive Educational Hypermedia Systems. Moreover, due to the significant amount of time, money and effort devoted to creating online courses, developers strive to incorporate standards, such as SCORM, for the reusability, interoperability and durability of the educational content. However, it is a difficult task for teachers without programming knowledge to design and author adaptive courses. This work presents ProPer SAT, an authoring tool implemented for quick and easy SCORM courseware construction which can also be adapted to specific user learning styles.

Keywords: adaptive hypermedia, learning styles, SCORM, course authoring.

1 Introduction

Online courses are one of the most popular means of distributing knowledge worldwide. A large number of learners, irrespective of their abode, age or study constraints can have access to them, mainly through Learning Management Systems (LMSs). Since these learners have differences in the knowledge levels of the domain, educational goals, personal characteristics and learning styles, a lot of effort is devoted to the personalization of instruction with the intention of improving the learning outcome. Adaptive Educational Hypermedia Systems (AEHSs) aim to individualize the learning process to meet students' characteristics. The development of these systems, however, is not based on a common framework, as there are no fixed rules, techniques or methods acceptable to all. Consequently, although developers spend a lot of valuable time, money and effort on their applications, they pay nowhere near enough attention to instructional strategies. Moreover, due to the absence of a common framework, the courses along with the educational content produced are deficient in reusability, interoperability and durability. More specifically, it is difficult to apply the educational content from one course to another; or to distribute a course from one AEHS to another, since most times they are not compatible. A proposed solution to this problem is the adoption of recently accepted educational standards.

The most popular education standard is SCORM (Sharable Content Object Referenced Model) [1]. In previous work [2][3] we combined the adaptive features of AEHSs with the adoption of the SCORM standard and its specifications. Furthermore, we promoted the concept that it is possible for native SCORM compliant courses to

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be adapted to user learning style [4]. Despite all of this, however, instructors still need to invest a great deal of effort to construct adaptive SCORM compliant courses, which apart from the SCORM framework, also require knowledge of learning style theories, and programming capabilities (JavaScript, HTML). It is therefore inevitable that instructors with little or no prior programming knowledge come up against difficulties during course construction, as there is a definite lack of easy authoring tools for non-programmers.

In this paper we propose a framework for easy authoring courses that are SCORM compliant and/or adaptive to learning styles. We present an authoring tool named ProPer SAT that enables authors, with no prior knowledge of programming, or SCORM specifications, to construct quick and easy adaptive SCORM compliant courses. These can instantly be distributed by ProPer - an adaptive SCORM compliant LMS we have developed - or exported as a SCORM package for later use by any SCORM compliant LMS. The paper also includes a short description of the SCORM specification, AEHSs technology and the possible adaptation to learning styles of these systems. In addition, work related to adaptive systems with adaptation to learning styles, SCORM compliant systems, and course authoring tools are presented. Moreover, an introduction of the developed authoring tool as well as a discussion of the proposed framework are given. Finally, conclusions are put forward and further work recommendations made.

2 Theoretical Background

The proposed system combines technologies and characteristics from three domains of web based instruction research. It uses adaptive technologies, such as AEHSs, it conforms with SCORM specifications and incorporates adaptation to user learning styles. This section briefly presents SCORM standard, AEHSs and some of the most popular learning style models.

SCORM specification

The SCORM standard was developed by the Advanced Distributed Learning (ADL) initiative and is based on previous standards (AICC, ARIADNE, IEEE LTSC, IMS). Its main aim is to offer RAID (Reusable, Accessible, Interoperable, Durable) courses.

SCORM includes all the technical specifications that are necessary for the development, organization and distribution of the learning content. It is based on learning objects known as SCOs (Sharable Content Objects), which are the smaller logical entities that can be delivered by a compliant course and communicate with the LMS. Every SCO consists of information about the creation, discovery and aggregation of the appropriate educational resource in their most basic form (assets). Assets are digital media, such as text, images, video or any other digital data that can be delivered through a web based system.

The latest version of SCORM has three main components [1]: (i) The Content Aggregation Model (CAM), describes the parts used in a learning experience; how to package them for exchange; describe them for search and discovery; and define sequencing rules. (ii) The Run-Time Environment (RTE) defines the LMS requirements for managing and communicating with the educational material. RTE provides an

Application Program Interface (API) for communication between SCOs and LMS. (iii) Sequencing and Navigation (SN) describes the information and behaviors an LMS must apply to offer a designed learning experience.

Adaptive Educational Hypermedia Systems

AEHSs find user specific characteristics, preferences, learner progress and goals, in an attempt to personalize the learning experience according to these factors. They consist of three main components: (i) The Domain Model (DM) represents the system's domain knowledge; (ii) the User Model (UM) depicts the user's knowledge of the domain as well as his/her individual characteristics; and (iii) the Adaptation Module (AM) describes how the adaptation will be applied and which items will be adapted.

Adaptation is implemented using two major technologies: the first, Adaptive Presentation (AP) provides adaptation of the content level. It can adapt either the presentation and/or the content according to the factors stored in the UM. According to Brusilovsky [5] there are three main AP technologies: Adaptive text presentation, Adaptive multimedia presentation, and Adaptation of modality. The second is Adaptive Navigation (AN), which adapts the links or the course's link structure in order to steer the user towards certain links and away from others. The main AN technologies are: direct guidance, link hiding, link disabling, link removal, link sorting, link annotation, link generation, hypertext map adaptation.

Learning Styles

According to Honey and Mumford [6] learning style refers to a person's habits and patterns of behavior that determine the desired means of learning. Some of the best known learning style models are: Kolb's experimental learning model [7]; Honey and Mumford based on Kolb's model; the Felder and Silverman model [8]; the Witkin's Field Dependent/Field Independent model [9]; and Gardner's theory of multiple intelligences (MI) [10]. All have been used in several AEHSs with the intention of helping students gain a better learning outcome. The system we propose uses the Honey and Mumford categorization based on Kolb's model.

According to **Kolb's experimental learning Model**, learning is a process of knowledge construction through four distinct stages of a cycle: a) concrete experience (CE); b) abstract conceptualization (AC); c) reflective observation (RO); and d) active experimentation (AE). The student can start from any point in the cycle and continue in that order to pass through all the stages. This model distinguishes learners into four categories each representing the combination of two preferred styles: Divergers (CE-RO), Assimilators (AC-RO), Convergers (AC-AE) and Accommodators (CE-AE).

Similar to Kolb's the learning cycle in **Honey and Mumford model**, is consisted by four stages: a) Having an experience; b) Reviewing the experience; c) Concluding from the experience; and d) Planning the next step. The student can start from any point in the cycle and progress to the others. Each stage is related to a particular learning style. Thus, the corresponding learning styles are the: a) Activist, b) Reflector, c) Theorist, and d) Pragmatist.

3 Related Work

Currently many systems are attempting to incorporate adaptation to user learning styles. Next we can see some of them and the learning model they implement:

- INSPIRE [11] implements Honey and Mumford model;
- TANGOW [12], LSAS [13], CS383 [14] incorporate several dimensions of the Felder-Silverman model;
- AES-CS [15] adopts the FD/FI model;
- EDUCE [16] is based on Gardner's MI theory.

There are additional tools, which assist authors in the creation of adaptive courses. These systems allow the instructor to define specific rules in order to apply adaptation to the course or they provide ready instructional strategies. Below we briefly present some such systems.

AHA! [17] is an open source web server extension that adds adaptation to applications, such as on-line courses. WELSA [18] is a system consisting of an authoring tool and a course player. By integrating characteristics from several models, it creates a unified learning style model. It uses a set of metadata to describe learning content and it takes into account some behavioral patterns for learner tracking functionality. MOT [19] is an online environment for the authoring of adaptive educational hypermedia. In MOT the author can either select an adaptive strategy that corresponds to an instructional strategy created by a different author and apply it to an arbitrary concept map or lesson map [19] or define his/her own instructional strategy.

Most of the above systems are inappropriate for teachers who are non-technical and who have little or no programming knowledge. However, to their aid comes VIDET and REDEEM . VIDET [20] is a visual authoring tool for designing adaptive courses, whose goal is to support easy course authoring for non-technical instructors and attempts to give the teacher full control over the adaptive operations being performed. It provides authoring tools for manipulating the hypertext structure, the content, the user model and the adaptive interaction model. REDEEM [21] allows instructors with little technological background to import pre-existing courses and provides them with tools to define how they want to teach the material. Its focus is not on the construction of domain material but on authoring pedagogy.

Even if some attempts for reusable educational content have been made [19], all the above authoring tools do not conform to a standard such as SCORM. Thus, they have limited reusability. Even when many popular LMSs support SCORM courses (Moodle, Claroline, Web-CT) they do not include tools for course authoring. Hence, they support only the import of ready SCORM compliant courses developed by external SCORM authoring tools.

Some of the most common SCORM authoring tools are the systems Reload and eXe, available for free, both of which support SCORM package construction and SCOs metadata definition. A drawback, however, is that even though these tools provide fast course packaging implementation the author is still required to have good knowledge of SCORM specifications. Moreover, the educational content must be designed in an HTML editor or the author might even need to invest in expensive authoring tools, such as Lectora or Lersus editors. Worse still in the case were adaptive presentation of content to user learning style is required authors have to write in a more or less complicated JavaScript.

4 Introduction to ProPer

ProPer [2][3] incorporates a combined architecture of AEHSs and SCORM LMSs. It involves four main modules: DM, UM, AM (from AEHSs general architecture) and RTE Sequencer from SCORM LMSs architecture. Adaptive functionality can be provided in two ways: AN using the system's Adaptation Module and AP and/or some AN technologies by taking advantage of SCORM functionality at the course authoring phase. Both formative [3] and summative evaluation of ProPer have completed. Formative evaluation results demonstrated that students using ProPer can navigate more goal oriented into a course, avoiding unnecessary concepts. As a result a course can be accomplished faster. Furthermore, summative evaluation results verified that ProPer can improve the learning outcome in comparison with a simple hypermedia system. In addition, users stated that they like studying with ProPer and they find it simple and useful. Writers are also found ProPer very easy and useful for their courses delivery since it allows them design personalized instruction. At the same time, existent educational material can be easily retrieved, accessed and reused taking advantage of SCORM functionality.

SCORM not only excels in reusability issues but also allows authors to design both sequential and content instructional strategies. In particular, authors can create educational content in the form of HTML pages. These pages have to include the appropriate JavaScript to communicate with the LMS. Moreover, every SCORM conformant course must contain an xml manifest file, which includes all the data for course structure, SN. In previous work we have shown that SCORM standard allows compliant courses to provide adaptivity according to user learning styles [3]. However, as is known, designing a course that is adaptive to user learning style is not an easy task. Although a framework for applying learning styles to SCORM compliant courses has been proposed [4], the implementation of these adaptive courses requires that authors have programming skills and deep knowledge of the SCORM standard. Therefore, we decided to design an authoring tool that allows non-programmer authors to create SCORM compliant and/or adaptive courses.

5 ProPer SCORM Authoring Tool (SAT)

ProPer SAT is a simple online SCORM authoring tool for both web page design and course package creation enabling tutors to effectively and efficiently design SCORM compliant adaptive courses. Its focus is on simplicity with the intention of attracting instructors with a low technological background. The main goals of ProPer SAT are: Help instructors compose SCORM compliant courses; Provide course patterns for easy authoring of adaptive courses to user learning styles; and Enable easy reusability for both SCOs and content fragments.

In order to keep the tool simple we do not provide advanced sequencing options with prerequisites and conditions for SCORM compliant courses. For these actions

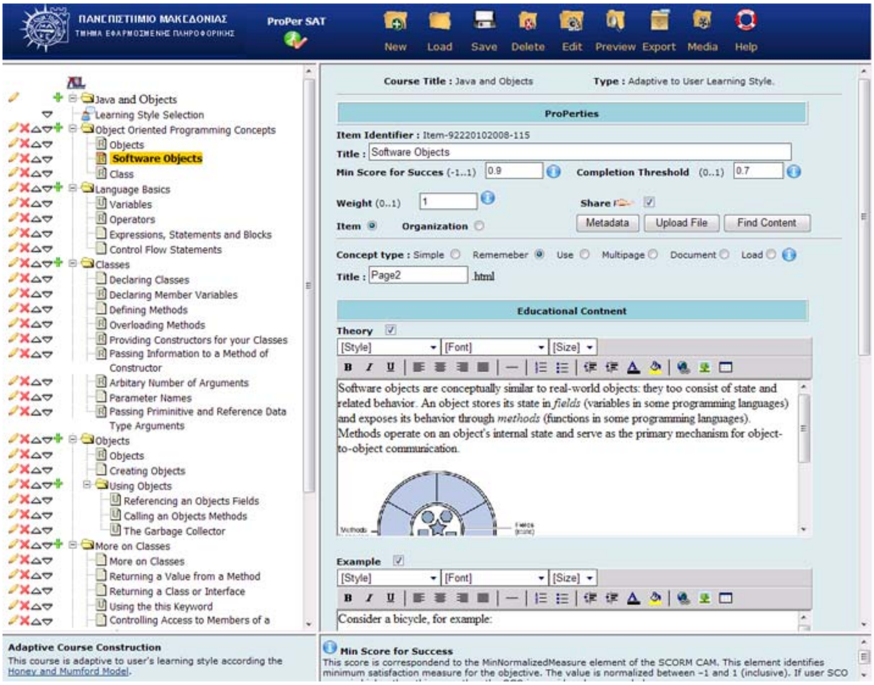

Fig. 1. The ProPer SAT interface

the author may use a dedicated SCORM package editor, such as Reload. On the other hand, the prototype does support content writing, course structure construction and course packaging functionalities. Moreover, the system enables instructors to easily create adaptive courses according to the Honey and Mumford model through a guided authoring process based on a framework we have proposed elsewhere [4].

The ProPer SAT interface is comprised of four main frames (Fig. 1). At the top of the page the toolbar functions are related to the whole course. On the left- hand side, a tree view of course structure and possible actions relative to course items/organizations is presented. The screen's main frame contains all the appropriate properties of course item/organization. In the case where the current selection is an item (SCO), WYSIWYG editors appear that enable the author to easily compose the educational content. The bottom of the screen is divided into two frames that contain information on the course and help about available options.

Authoring

Particular care was taken to ensure that authoring of courses remain as simple as possible. An initial screen (Fig.2) allows the author to give a title and select the course type. So far there are two types available: Simple SCORM courses without adaptive presentation and courses adaptive to user learning style. The latter adopts the Honey and Mumford model whose implementation is used by ProPer and INSPIRE. Beside the course type options a simple explanation is displayed. Moreover, the author can select one of the predefined templates for the course interface. A picture with a

Fig. 2. New course options

preview of the selected template is displayed on the right hand side of the screen for better usability. Once the author has made their selections they can begin creating the course by pressing the appropriate button at the bottom of the screen.

In the next step a screen identical to Figure 1 is displayed with the initial course structure. For a simple course initially only the title with the "add" option (+ symbol) appears in the tree view. In the adaptive type courses, however, a predefined SCO for learning style selection has been added, which now allows authors to add items or organizations to their course. For every new item the author has to define item properties or leave the default as is. The user can also load an older SCO from the system's repository. With this option the system enables the author to find and use a SCO from other courses and/or authors. Once the SCO is inserted the author can proceed by manipulating both its properties and contents. Authors can also provide some of the metadata information that SCORM standard proposes. This metadata can later be read for the retrieval and reuse of relevant educational material.

Following this, the author starts the content orientation. A choice has to be made between three or five content types for simple and adaptive courses respectively. The available content types are:

- Simple: where the user writes the content in a WYSIWUG editor;
- Multipage: when a SCO constitutes more than one page. Once the user selects this option he/she must state the page number and the appropriate number of WYSIWYG editors is presented for content writing;
- Document: where the produced page presents the content of a document, such as Word, Excel, PowerPoint etc.; and
- Remember or Use: these types are available only in adaptive courses. They allow the user to create content for different knowledge modules (Theory, Example, Question, Activity) within a SCO. These modules are presented in a different order according to the user learning style. The module selection and their adaptive presentation are based on the framework presented by Papanikolaou [11]. For instance, the modules' order in a Remember page for an Activist user will be Question,

Example, Theory; while for a reflector it will be Theory, Example, Question. A typical screen for the creation of a Remember content type is displayed in Figure 1.

During course creation the author can view the page by selecting the Preview button at the top of the screen. Once SCO creation has been completed it can be saved and a new one added through the icon on the course structure frame. The same procedure continues until completion of course construction. Furthermore, the author may select an item from the course structure frame in order to change its properties and/or content. Items can also be deleted or their positions changed. A noteworthy feature is that each item in the course structure frame is adaptively annotated. The course can be exported to a ZIP archive according to the SCORM 2004 3rd edition standard. Authors can either upload the course into any SCORM compliant LMS or proceed to further changes. The changes can be relative to the package, SN of the course or related to page content. These changes can be made with common SCORM package software and an HTML editor, such as Reload and Dreamweaver respectively.

System architecture and implementation
The system adopts a three tier architectural design (Fig. 3). The first tier is the system's front end, which is the client side of the prototype and involves the user interface. The middle tier contains the system's intelligence made up of the **Domain Model** (DM) and the **Course Production Module** (CPM). More specifically the DM reads data from the interface; it also forms and stores it onto the database. The CPM reads data from the database and dynamically creates the user interface. It communicates with the DM and the database, interprets user preferences into the appropriate XML or HTML code and creates all the required course files. Following, it compresses these files into a ZIP archive and delivers it to the user.

Lastly, Data Storage is the back end tier and contains the system's database as well as a file server, whose files fall into three categories:

- SCORM package files necessary for the creation of a SCORM package. These are copied as they are in the exported SCORM course packages. SCORM standard requires the existence of some standard files in every compliant course. Moreover, the produced courses are based on specific JavaScript and CSS files according to the selected type and template respectively. These files pre-exist in the system's file server.

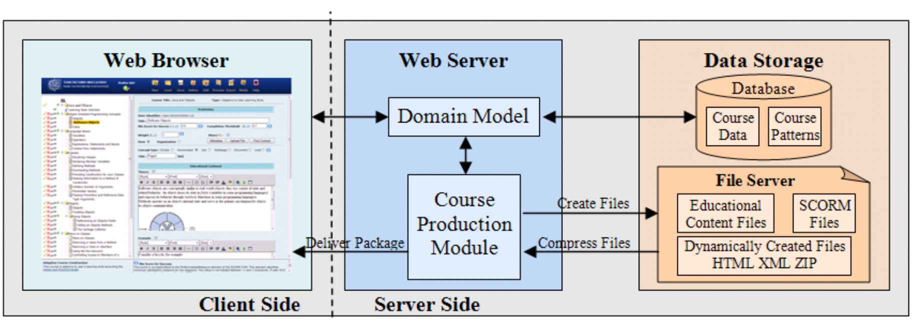

Fig. 3. System architecture

- Educational content files (photos, PowerPoint documents etc.) uploaded from users to appear on course pages. When users want to insert a photo or a presentation etc. into their course, they first must upload the file and later state it in the appropriate course SCO.
- Dynamically created files (HTML, XML and ZIP files) according to user preferences and submitted educational material. When the user chooses to export a course the system dynamically creates the HTML files with the course content and the imsmanifest.xml file necessary for the course package. In the final step it creates a zip file containing all the appropriate course material.

Apache Tomcat 5.5 used as a web and application server and MySQL 5 as a database server. Java Server Pages (JSP) and Java Servlets used for the middle tier intelligence while HTML, CSS and JavaScript for the front tier development.

6 Conclusion and Future Works

In this paper we have presented ProPer SAT, a tool for the efficient and effective construction of SCORM compliant and/or adaptive courses. Compared with the related work ProPer SAT and ProPer can create and deliver courses adaptive to user learning style in the same way that AES-CS and INSPIRE do, providing a tool for quick course production. Further, ProPer SAT is able to construct simple SCORM compliant courses along with their required educational content. ProPer SAT has an advantage over other simple authoring tools, such as MOT, VIDET etc. for its simplicity and SCORM standard adoption. Moreover, most of the SCORM compliant LMSs do not provide a tool for easy course construction nor do they support adaptive features as ProPer does. Even if advanced users can employ tools, such as Reload or Lectora etc., for course packaging and content development, our system provides an easy way for basic function implementation without needing to have programming skills or detailed knowledge of SCORM. In sum, ProPer and ProPer SAT offer a promising solution for non-technical teachers who want a simple way to be able to create and deliver SCORM compliant and/or adaptive courses quickly and easily.

ProPer SAT is still in the process of development, therefore, some features have not as yet been implemented. Despite our conviction that its prototype, as it stands, is an exceptionally useful tool for teachers, more functionality needs to be added. Our goal is not to make this tool support the implementation of all the SCORM functionalities, however, a possible use of SCORM rules and conditions is under study. ProPer SAT will help authors create adaptive courses and define sequencing and navigation procedures. Moreover, some additional course-content types, such as tests, can be added to support user assessment. Finally, a pilot operation and evaluation of system effectiveness will follow in order to check for any system weaknesses, as well as assess the system's functionality, usability and usefulness. It is imperative to note, however, that the simplicity of the authoring process, which is the driving principle behind the development of ProPer SAT will not be compromised to any extent, irrespective of any future changes that may be warranted.

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An Evaluation of the Impact of E-Learning Media Formats on Student Perception and Performance

Karl Kurbel, Ivo Stankov, and Rastsislau Datsenka

Europa-Universität Viadrina Frankfurt (Oder), Große Scharrnstr. 59,
15230 Frankfurt (Oder), Germany
{kurbel.bi,stankov,datsenka}@euv-frankfurt-o.de

Abstract. Factors influencing student evaluation of web-based courses are analyzed, based on student feedback from an online distance-learning graduate program. The impact of different media formats on the perception of the courses by the students as well as on their performance in these courses are examined. In particular, we studied conventional hypertext-based courses, video-based courses and audio-based courses, and tried to find out whether the media format has an effect on how students assess courses and how good or bad their grades are. Statistical analyses were performed to answer several research questions related to the topic and to properly evaluate the factors influencing student evaluation.

1 Introduction

1.1 Background and Motivation

In technology-supported teaching and learning, various formats for the delivery and presentation of course material have been used. In the absence of crisp guidelines, creators of courses and study materials usually choose a delivery format based on their personal preferences, on what is "common", or on what they feel is the best choice for the particular topic under consideration.

Discussions about the influence of specific media formats on CBT (computer-based training) can be traced back to the late 1980s when a number of studies exploring the new horizons of computer-enabled learning were published (e.g. [2]).

Recent studies dealing with the topic include the works of E. Wiebe and L. Annetta [5], S. Park and J. Lim [4] and E. Engh et al. [1]. However, after a decade of research there is still no definitive answer to the question of what is the best way to deliver and present learning material in CBT.

1.2 Media Formats

The media formats examined in this paper have been employed in a graduate distance-learning program offered exclusively over the Internet for several years. The courses included in the research cover topics from the field of business informatics and were initially created in 2001/2002. Since then they have been taught every year without significant changes regarding the course content, structure or media format.

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The media formats, that were examined are the following:

Type 1: Video-based course – Video-based courses are most similar to a classical face-to-face lecture in a brick-and-mortar university.

Type 2: Hypertext-based course – As in conventional distance education, the main content delivery format is text. However, all material is provided electronically. It can be viewed with a browser and explored in a non-linear pattern.

Type 3: Audio-based course – This type is similar to type 1. As in a traditional classroom course where the lecturer uses transparencies for illustration, a sequence of slides (e.g. PowerPoint slides) synchronized with an audio track is provided.

Type 4: Audio and text-based course – As in audio-based courses, slides and an audio track are provided, plus a text transcription. In this way, students can read the content while (or instead of) listening to it.

It is important to note that the contents of all the courses underlying this research are derived from, and could also be offered in a classical face-to-face lecture setting and in any of the media formats mentioned above.

1.3 Research Questions

This paper seeks to address some of the issues cited as lacking in previous researches as mentioned above. In particular:

1. Does the media format (i.e. the way course content is delivered and presented) have an influence on the assessment of a course by the student?
2. Does the media format influence student performance (in terms of grades achieved)?
3. Does more "dynamic" course content receive better evaluations than static course content? (In particular, video-based courses [3] vs. hypertext-based courses.)

2 Data and Statistical Tools Used

2.1 Data Sample

The courses of the master's program are evaluated by students each semester with a questionnaire. One dataset was generated from student feedback collected at the end of each semester between winter semester 2001/2002 and winter semester 2007/2008 (called EVAL dataset). The second dataset (called GRADE dataset) contains the students' performance in the same courses, according to the ECTS grading system.

2.2 Methodology and Statistical Tools

Cronbach's alpha was computed to prove the reliability of the collected data. In general, only nonparametric methods (sometimes called distribution-free) were applied to Likert scale data from both datasets. The hypothesis of normality was checked with the help of both Kolmogorov-Smirnov and Shapiro-Wilk tests of normality. The differences among all groups were tested with the help of the Kruskal-Wallis test, and between two particular course types, with the Mann-Whitney U-test. The level of significance (alpha level) was $p = 0.05$ for all tests.

3 Analysis and Interpretation of Results

3.1 General Observations

The first hypothesis based on research question 1 is:

H1: If a particular course type was evaluated by the students significantly differently as compared to the whole population, then this inhomogeneity will be visible in the test results.

The hypothesis based on research question 2 is:

H2: Student performance depends on the type of course.

The statistical analysis led to the following findings:

1. The EVAL dataset exhibits no statistically significant differences between course types apart from questions involving the measurement of the difficulty. It was shown that no special preferences exist toward particular course types in the examined population as a whole.
2. The only inhomogeneity factor in the EVAL dataset is difficulty. Video-based courses were confirmed to be the most difficult ones among the 4 course types.
3. The GRADE dataset exhibits statistically significant differences between course types. This means that research question 2 can be answered positively.
4. Video-based courses received the best evaluations by the students.
5. A comparison of the mean ranks gives a strong impulse towards comparing the student evaluations of video-based and hypertext-based courses. Even though no differences in the evaluations of the 4 types exist as a whole, differences between groups, when compared pair-wise, might be significant (see next section).

3.2 Video-Based versus Hypertext-Based Courses

According to research question 3, the hypothesis is established:

H3: Video-based courses obtain better evaluations from students than hypertext-based courses.

According to statistical observations (comparison with a Mann-Whitney test) we concluded that a more "dynamic" mode of multimedia content delivery (such as videos) in distance learning is better accepted than a rather static mode – namely reading an instructional text.

Despite the perceived difficulty and low average grades, students nevertheless prefer to obtain the learning material in a multimedia form, similar to a traditional campus-based lecture. Hypertext-based courses, being not so "entertaining", are evaluated significantly worse.

4 Summary and Conclusions

The three research questions put forward at the beginning of this paper were answered with the help of statistical tests. Based on the students' evaluations and performances, the answers can be summarized as follows:

1. In terms of student perception, the different course types seem to be evaluated quite similarly.
2. Student performance in a course – in terms of the grades students receive – seems to depend on the content delivery type of the course. (However, this conclusion might be biased because possibly the subject matters of these courses are more difficult as such.)
3. Despite its perceived difficulty, the video-based course format proved to be the students' favorite. This course type was evaluated significantly better than the more conventional hypertext-based courses.

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Evaluating Pedagogy-Driven Design of IVA LMS with Activity Pattern Analysis

Mart Laanpere, Kai Pata, and Vladimir Tomberg

Tallinn University, Institute of Informatics, Centre for Educational Technology, Narva road 25, Tallinn 10120, Estonia
{Mart.Laanpere,Kai.Pata,Vladimir.Tomberg}@tlu.ee

Abstract. This paper discusses a pedagogy-driven approach to designing new online learning environments, illustrated by a case study on IVA LMS that was developed in Tallinn University. An empirical study was carried out on the seventh year of using IVA LMS, server log analysis revealed three different types of learning paradigm related activity patterns that were used by teachers and students in IVA environment.

Keywords: learning management systems, activity patterns.

1 Introduction

Learning Management System (LMS) IVA [5] was designed in Tallinn University using pedagogy-driven approach. This approach is defined by the belief that through designing the affordances of the online learning environment in line with certain pedagogical model, the user behavior patterns can be changed so that they are more compatible with contemporary educational theories, especially social constructivism.

In order to evaluate the impact of the IVA design on users' activity patterns as our main research problem, an empirical study was carried out in 2008 when IVA has been in use for six years as the primary e-learning environment in Tallinn University.

The study was focusing on the following research questions: (1) Which activities tend to co-occur during an IVA session? (2) Which learning paradigm related activity patterns are used in IVA environment?

2 Pedagogy-Driven Design of LMS

From the constructivist point of view, learning is an active process of constructing rather than acquiring knowledge [2]. Social constructivism has been accepted as the mainstream educational theory also in the domain of educational technology, D.H. Jonassen being one of the spokesmen for this paradigm among others. Jonassen's 3C model [3] synthesizes the key constructs from several contemporary theories of learning and instruction, focusing on three central aspects of designing constructivist learning environments:

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1) teacher/facilitator should create an authentic Context for learning,

2) sufficient time, space and scaffolding for personal knowledge Construction should be provided to every learner, and

3) social negotiation of meaning should be supported through active Collaboration between learners.

One of the impulses that led our team to initiate the development of IVA LMS was the perception of the instructors that the affordances of "pedagogically netural" WebCT implicitly call for a simplified behaviorist model of online teaching and learning activities: read the next unit, then practice using some self-tests, then fill in a multiple-choice quiz. Things were not much different with the systems that had been claimed to be "pedagogically-biased". For instance, the affordances of allegedly "constructivist" [1] Moodle LMS and activity patterns of learners in Moodle-based courses seem to be quite similar to the ones of WebCT. When we compared affordances of eight different LMSs with regard to their compatibility with the principles of social constructivism, only one of them seemed to come close: it was FLE3 [6]. IVA LMS was then built as an extension of FLE3. Three pillars of pedagogy-driven design of LMS were identified as follows:

1) the use of pedagogically rooted vocabulary in the user interface,
2) pedagogically motivated structure and design of the user interface,
3) built-in activity templates that are drawn from certain pedagogical approaches, techniques, or methods (e.g. Progressive Inquiry or Six Hats).

Directly drawn from the 3C model by Jonassen [3], the user interface of IVA is structured into three sections:

- Webtop (personal knowledge Construction area) – learner's personal, web-based „workbench", containing Portfolio, Blog, folders and journal.
- Bookshelf (area for establishing a meaningful Context for learning) – the place where learning resources and guidelines are provided by teachers
- Workshops (Collaboration area) – section for group work and discussions, containing Knowledge Building Forum, Jamming tool for collaboration, subgroup portfolios and a collaborative concept mapping tool.

In addition to these three sections, there is the Management section accessible for teachers only (for enrolling course participants, preparing tests etc) and administrator.

IVA is an open-source Zope-based product, programmed in Python language [5]. It is currently used by about 20 000 students in 23 educational institutions in Estonia.

3 Empirical Study

Data for the analysis were received from the Web server logs for academic year 2007/2008 on the IVA server of Tallinn University. As the Web traffic database for whole academic year was too large to be analyzed with our means, analysis was based on data from May 2008 only. Within this month 1563 unique users used IVA system, among them 1506 students and 57 teachers. Students initiated 14676 Web sessions during which 133485 unique HTTP requests for IVA pages were made. Teachers initiated 872 Web sessions with 12700 unique HTTP requests. By analyzing the recurring sets of activities that were carried out during one session, we tried to define typical pedagogical activity patterns that could help us to explain how different groups of people with certain pedagogical thinking behave in the system. Below follows the analysis and discussion guided by two research questions.

1. Which activities tend to co-occur during an IVA session?
The Spearman's rank correlation analysis was performed separately for students' and teachers' activities in order to investigate the repeating co-occurrences of certain activities during an IVA session. Figure 1 demonstrates that an average student uses higher variety of activities during one session in comparison with teachers. The use of both Bookshelf and Workshops by students during one session is likely to happen, but interestingly there is no correlation between the use of Bookshelf and Webtop. A plausible explanation here could be that teachers seem to relate uploaded materials on Bookshelf more often with collaborative assignments carried out in Workshops section (e.g. using forum or small-group portfolio), rather than with personal knowledge construction assignments that are stored on personal Webtop. Knowledge-building forum is likely being used by students together with personal Webtop within one session. Interrelations existed also between Subgroups, Wordmaps and Knowledge-building forum indicating that these collaborative knowledge-construction activities were frequently performed in parallel. Test activity (multiple-choice quiz or self-test) showed high level of co-occurrence with Workshops, indicating that students were sharing some information with each other either before or after completing the quiz.

2. Which learning paradigm related activity patterns are used in IVA?
Simple frequency and correlation analyses of activities does not reveal how often certain activities are used together, in combination with each other. For analytical purposes three learning activity patterns of using IVA were determined, which could be related with different learning paradigms:

- Knowledge building: all activity patterns in which Knowledge-building, Subgroups or Workshops were used;
- Knowledge testing: all activity patterns in which Testing activity was used;
- Knowledge distribution: only storing/retrieving in Webtop and Bookshelf.

ANOVA results showed that these activity patterns differed significantly (p>0.001) from each other. Fig. 2 illustrates the mean frequencies of activities for each pattern.

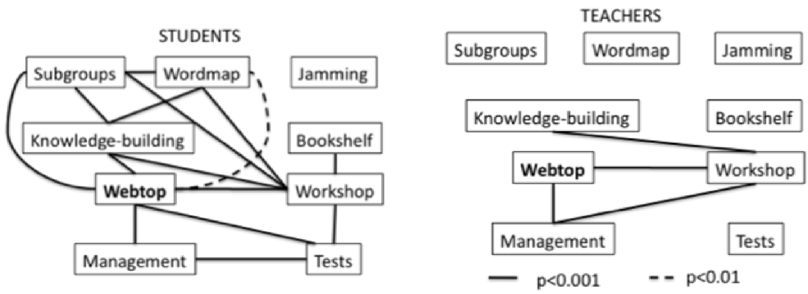

Fig. 1. Correlations of students' and teachers' activities that appear together in IVA sessions

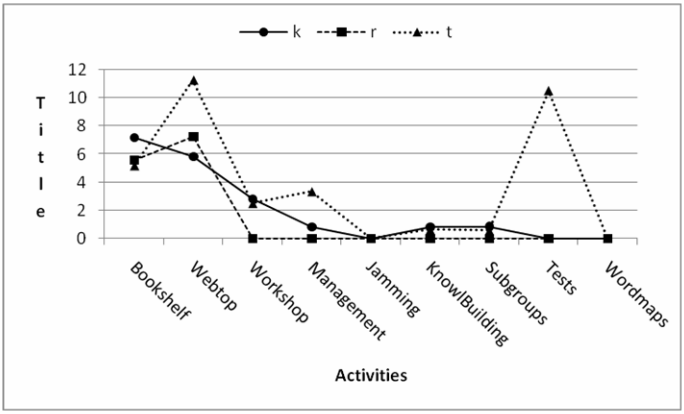

Fig. 2. Mean frequencies of activities in Knowledge building (k), Knowledge distribution (r), and Knowledge testing (t) activity patterns

The analysis revealed that the Knowledge building pattern was most frequently used (78 % of students, 83 % of teachers) in IVA LMS (see Fig. 3).

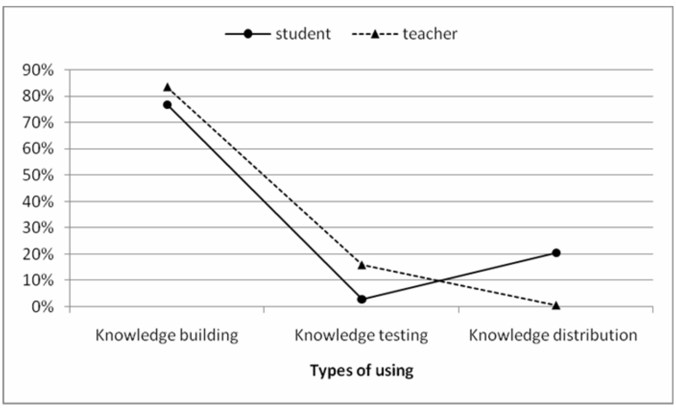

Fig. 3. Students' and teachers usage of Knowledge building, Knowledge distribution, and Knowledge testing activity patterns in IVA

About 20 % of students, yet only about 1 % of teachers used only the Knowledge distributing pattern. About 16 % of teachers and 2 % of students used the in sessions Knowledge testing pattern. Chi square analysis demonstrated that students' preference to use Knowledge distributing pattern and teachers' preference to use Knowledge Testing pattern more frequently than expected was significant ($chi^2=278.37$, $df=2$, $p<0.001$). Notable is that there exists the difference in students' and teachers' preference of using these patterns. It is clear that while minority of teachers use e-courses only for storing learning materials to give access for students, but there exists quite many students (20 %) who use LMS only as a learning resource repository and do not participate in knowledge-construction activities.

4 Conclusions

While simple frequency analysis suggested that IVA was mainly used for storing and retrieving course materials, the more complex pattern frequency analysis revealed that many teachers and learners use constructivist learning activities and the retrieval of static learning resources from IVA is only part of this pattern. Since the usage of Knowledge testing activity appeared not very frequently among students, it can be assumed that most of the teachers probably design various knowledge construction activities for assessing the learning outcomes of the students. Although we cannot attribute the prevalence of social constructivist activity patterns among the users of IVA directly to the pedagogy-driven design of IVA LMS, the results of empirical study have encouraged us to initiate the development of the next generation online learning environment using pedagogy-driven design in more systemic manner, with built-in activity pattern analysis tools.

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Automatic Content Creation for Games to Train Students Distinguishing Similar Chinese Characters

Kwong-Hung Lai, Howard Leung, and Jeff K.T. Tang

Department of Computer Science, City University of Hong Kong, Hong Kong
{kwonglai,howard}@cityu.edu.hk, kttang@cs.cityu.edu.hk

Abstract. In learning Chinese, many students often have the problem of mixing up similar characters. This can cause misunderstanding and miscommunication in daily life. It is thus important for students learning the Chinese language to be able to distinguish similar characters and understand their proper usage. In this paper, we propose a game style framework in which the game content in identifying similar Chinese characters in idioms and words is created automatically. Our prior work on analyzing students' Chinese handwriting can be applied in the similarity measure of Chinese characters. We extend this work by adding the component of radical extraction to speed up the search process. Experimental results show that the proposed method is more accurate and faster in finding more similar Chinese characters compared with the baseline method without considering the radical information.

Keywords: Automatic content creation, game, similar Chinese characters, radical extraction, e-learning.

1 Introduction

Nowadays there exist many e-learning applications to help students learn their native or a foreign language. This paper is focused on the learning of the Chinese language. The research in [1][2] provide an interactive interface for students to practice Chinese character handwriting. These e-learning methods help students improve their handwriting skill by providing them a framework to repeat some handwriting exercises just like in the traditional learning. They have not considered how to maintain students' motivation to complete the tasks. Green et al. [3] suggested that game should be introduced for learning because games bring challenges to students, stimulate their curiosity, develop their creativity and let them have fun.

One of the common problems in Chinese students' handwriting is mixing up similar characters and misusing them. Those similar characters have similar appearance but their meanings are quite different. Some web-based games aim to help students differentiate similar characters [4]. However, they suffer from the drawback that the question-answer set is limited thus players feel bored easily and there is little replay value. On the other hand, creating a large set of question-answer pairs is time consuming if it is done manually. It is beneficial to have a system to generate the choices automatically.

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2 Related Work

To generate the game contents with similar characters automatically, the system needs to search for similar characters used in idioms or words to generate the choices such as (如火如茶 or 如火如荼 ?) and (人士 or 人仕 ?). In the above examples, only one of the two choices is correct and the other wrong choice has a character replaced by another similar looking character. These examples illustrate the possibility of automatic generation of the answer choices provided that there is a way to find similar Chinese characters. Many researchers developed different approaches in evaluating the similarity between Chinese characters [5][6][7][8][9][10][11]. In [5], the similarity is determined by matching the stroke length only. The processing is fast because the system does not use all the coordinates of each stroke. However, this approach does not work when there are missing or extra strokes in the character. The work in [6] accounts for the shear, scaling and rotation deformations before matching however similar characters are not only different in spatial distortions. The authors in [7] proposed a multi-resolution image-based approach in character recognition but strokes may be divided into layers in a different way for the same character with writing variations. Stroke primitives are extracted from the character in [8] for indexing but it is prone to errors in recognizing each primitive. In [9], character similarity is measured by comparing the spectrum of projections however certain similar characters are different in shape thus it may not be possible to use this approach to identify them. The algorithm in [10] depends on a knowledge base of similar characters from domain experts which requires a lot of manual efforts because there are many types of similar characters. Another approach recognizes the characters by breaking a character into radicals [11]. Inspired by the radical extraction proposed in [11], the radical information can be used to coarsely classify a Chinese character into a few groups according to its structure so that the search range for similar characters can be reduced. Moreover, the radical information is semantically meaningful for people with knowledge in the Chinese language. This makes the administrators, who are not familiar in programming, maintain the system easily.

In this paper, we propose a framework that includes a game with two difficulty levels to help students distinguish similar Chinese characters and master their correct handwriting skill. The game content is generated automatically using the similarity measure proposed in our prior work. We extend this work by including the radical extraction module to speed up the searching time while increasing the precision at the same time.

This paper is organized as follows. The proposed framework including the game play and game content creation is described in Section 3. The experiments and results are presented in Section 4. The survey for user comments is included in section 5. The conclusion and future work are provided in Section 6.

3 Proposed System Description

3.1 System Overview

The proposed system is developed as a web-based game and the system flow is shown in Fig. 1. During the game content creation stage, teachers are required to enter the

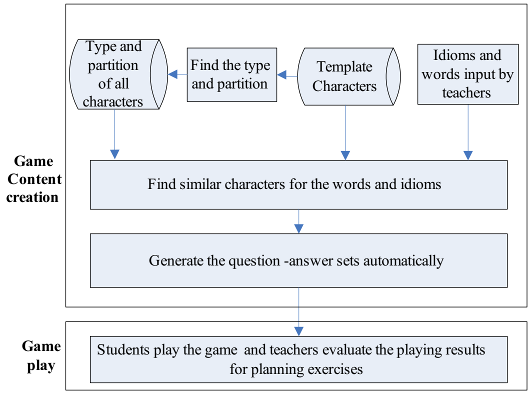

Fig. 1. Flowchart of proposed system

idioms and words once and then the system can automatically generate the game contents with similar characters in order to reduce the teachers' workload. In game content creation, similar characters will be searched in the database according to their similarity among template characters. The structures in terms of type and partition of the characters have been considered during searching. Prior determination for the type of a character can narrow down the search range. Afterwards, the system can compare the template characters and obtain their similarity value. Determination of the structure of the character and the similarity computation will be explained in section 3.3. During the game play stage, students can play the game with an interactive interface in two levels: easy and hard. After students finish playing the game, the teacher can evaluate their performance and plan the exercises.

3.2 Game Play

Each of the games contains two modes that were designed with different difficulty levels. The easy mode requires the user to identify similar characters with hints as shown in Fig. 2(a). For example, with the easy mode, the multiple choices consist of idioms or words with a pair of correct / incorrect answer is shown, where one of the characters is replaced with a similar looking character. If the students choose the correct answer, they are rewarded with score. If they choose the wrong answer or if time runs out, then the correct answer is shown. The hard mode requires the students to write down a character similar to the answer using a pen-based input device as shown in Fig. 2(b). Students are required to have the skill for correctly writing the characters without any hint in order to master this game. After writing down the correct answer, students are rewarded with score. They will be notified if the wrong answer is provided. To facilitate their learning, if students write the character with the wrong stroke order, the correct stroke order is shown with animation and text feedback. If students do not know the answer, they can click the answer button to see the animation of the teacher's writing on how the correct character should be written.

(a) Easy mode (b) Hard mode

Fig. 2. Game Interface

3.3 Game Content Creation

Teachers can simply enter Chinese expressions such as idioms or words into the database once and the system can generate the game contents with similar characters automatically. The main function of the proposed approach is searching for the similar characters in order to decide the questions automatically. It is possible to generate different questions by using various combinations of similar characters resulting from each Chinese expression. Our proposed work can thus reduce the workload for human to create a huge size of questions with different similar characters. This process involves searching all the characters in the database to identify similar characters. To facilitate a more efficient searching, we propose to apply the radical extraction algorithm to limit the set of candidate characters according to the structure. For this purpose, radical extraction method [11] is used to narrow down the search range. The stroke correspondence from our prior work [12] is used to measure the similarity of characters. The top few most similar characters will be returned and this information is used to generate the questions in the game for both modes.

3.3.1 Radical Extraction

According to [11], all the characters can be classified into three types: upper-lower(UL), left-right(LR) and other(O). The Chinese characters ‘昌’, ‘明’ and ‘中’ correspond to the UL, LR and O types respectively. We can divide a UL and LR type characters into two or more partitions: front radical and rear radical. The front radical of the UL or LR type is the upper part or left part of the character respectively. The lower part of the UL type or the right part of the LR type character is the rear radical. This information can help us to narrow down the search range and reduce the searching time. The type and partition are semantically meaningful for a lot of Chinese, so it will be easy for anyone to verify the type classification the database.

The processing steps can be divided into 3 stages. In Stage I the potential candidate types are determined. In Stage II some false candidates are removed according to the transition from the front radical to the rear radical. In Stage III the remaining false partitions are eliminated by region merging.

After all three stages, the type of the character can be determined. If only a LR candidate type remains, then it is a LR type character. If only an UL candidate type remains, then it is an UL type character. Otherwise, it is an O type character.

3.3.2 Similarity Measurement

After the types of the characters are determined, the search range can be limited according to the particular radical types. For example, for the example '仁' which is an LR type, the system searches all the characters with the same LR type cutting the front radical after the 2nd stroke in the database. To perform stroke matching, the cost matrix is formed and the stroke correspondence can be determined by minimizing the total cost of the matched stroke pairs using the Hungarian method [13]. The similarity is measured by getting the information of problematic strokes from the character pair [12]. The problematic strokes refer to the non-matched strokes or matched strokes with large matching cost. The idea of problematic strokes is explained by the example in Fig. 3. The stroke correspondence between the characters of '仁' and '付' is obtained. To avoid confusion, the two characters to be compared are using different stroke numbering scheme, i.e. (1, 2, 3, 4…) and (A, B, C, D…) respectively. The first three matched stroke pairs (1 and A, 2 and B, 3 and D) are not problematic because the matching cost is low. The fourth matched stroke pair (4 and E) is problematic because the matching cost is high. The last stroke of '付' has no matched stroke in '仁' thus it is an extra stroke hence problematic.

The similarity measure is calculated based on the number of problematic strokes according to the following expression:

$$similarity = (ns - np) / ns \tag{1}$$

where *ns* is the average number of strokes between two characters and *np* is the average number of problematic strokes. For the example in Fig. 3, *ns* = 9/2 = 4.5 and *np* = 3/2 = 1.5, thus *similarity* = (4.5-1.5)/4.5 = 0.66.

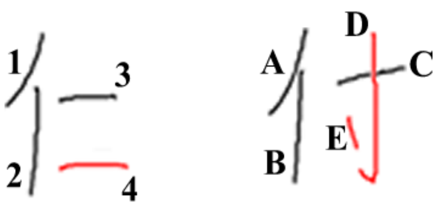

Fig. 3. Problematic strokes between two characters

3.3.3 Generating Game Contents with Similar Characters Automatically

After searching for similar characters in idioms or words, the system can generate the questions with similar characters.

Fig. 4 illustrates this process with the example of the idiom '如火如荼'. Assume that there are five characters '荼', '茶', '其', '奇' and '木' in the template character database. The similarity between each character in the idiom and the characters in the template database is shown. The characters '茶', '荼' highlighted in the example are considered as similar because there is one problematic stroke only, so their similarity value by equation (1) is higher than a predefined threshold. The system then creates a question with two choices, A: '如火如茶' and B: '如火如荼', given these two similar

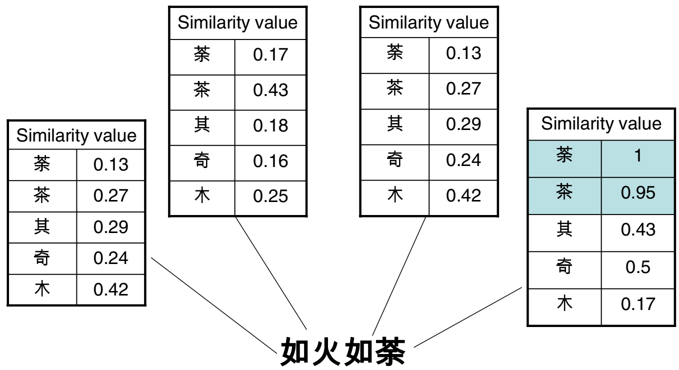

Fig. 4. Generate question from similar characters

characters and the idiom. As the number of template character in the database increases, it is more likely to find more similar characters thus increasing the number of options for the questions created with similar characters. Students or users can see different choices in the question and make them feel more challenging.

4 Experiments and Results

4.1 Threshold Value for the Similarity

In this experiment, 400 characters are selected randomly as query from our database of 982 characters. Three characters with the highest similarity values are returned for

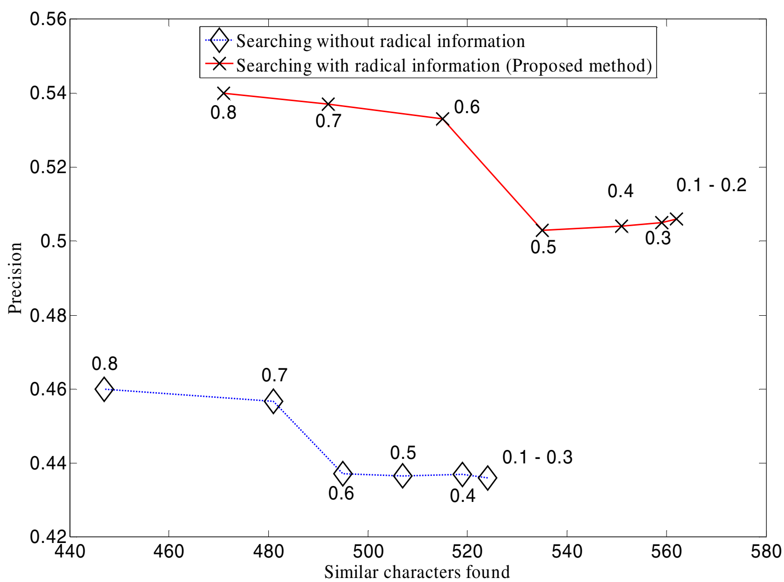

Fig. 5. Results using different threshold values for the two methods

each query using our proposed method. As a comparison, we also perform the same experiment using the similarity measure without the radical extraction module. We manually examine these results to determine the ground truth similar characters to evaluate the accuracy. The result in terms of precision versus the number of similar characters found using different threshold values with the two methods is illustrated in Fig. 5. The marker labels in the curves correspond to the threshold values. It can be seen that our proposed method outperforms the approach without radical extraction as the precision is higher with the same number of similar characters found. The threshold value for our proposed approach is set to be 0.5 and the threshold value for the other approach is set to be 0.6 as it is the starting point of the flat region of the curves.

4.2 Results

To further compare the two approaches, the total time in searching and accuracy are considered for more characters. In this experiment, 856 characters are used as query and the three characters with the highest similarity values are returned. The result is summarized in Table 1. The precision of the proposed method reaches 59.9% and is better than the precision of the searching without the radical extraction by 10%. Moreover, the average searching time is decreased from 3.03 second to 0.77 second per character. The significant speed increase is due to the limited search range narrowed down by the information of radical type and partition.

Table 2 shows some case analyses of both searching methods. In Table 2(a), the proposed method can find the characters with similar shapes such as the example of '肓''and '盲' which are UL types with front radical partition at the 3rd stroke. On the other hand, there is also false alarm in our current proposed approach as indicated in Table 2(a). This problem is caused by the fact that we do not consider the relative spatial relationship in the matching. Another problem corresponds to the missing cases. In the example character pair '他' and '也', '他' is classified as LR type, but '也' is O type thus this character is not included in the search range. We will improve this aspect in the future. On the other hand, Table 2(b) shows the result of the method without using radical information. The similar cases are the same as the O type characters in our proposed method. The advantage of this method is that it does not skip any characters in searching. However, this method does not consider the structure of the character, thus false alarm such as the character pair '商' '肓' may be obtained. Judging from the overall performance, it is still justified to employ our proposed method considering the tradeoff between the precision and speed.

Table 1. Final result on the two methods

	Searching without radical information	**Proposed method with radical information**
Total no. of actual similar characters	1101	1119
Total no. of similar characters returned	2213	1867
Precision	49.7%	59.9%
Total searching time	1 hr 52 min	24 min
Average searching time per character	3.03 sec	0.77 sec

Table 2. Cases analysis on the two methods

(a) Some cases of our proposed method with radical information

Correct cases	
Upper-Lower (UL)	[肓 盲], [茶 荼], [字 宇], [電 雷]
Left-Right (LR)	[佚 仗 伏], [佔 估 佑], [佯 伴]
Other (O)	[交 文], [日 田 口], [乖 乘 垂]
Error cases	
False alarm	[目 丑], [丹 井], [亭 卒], [享 卓]
Missing characters	[他 也], [亥 咳], [加 伽], [兀 元]

(b) Some cases of searching without radical information

Correct case	
Similar	[亙 互], [卞 下], [佔 估], [日 田 口]
Error case	
False alarm	[商 肓], [令 夕], [什 介], [佚 央]

Table 3. Questions in survey

Questions
1. The games are interesting
2. The games are challenging
3. You can improve your ability in identifying similar characters after playing the games
4. You are satisfied with the searching result
5. You are satisfied with the searching speed
6. The system can reduce the workload of teachers in creating games

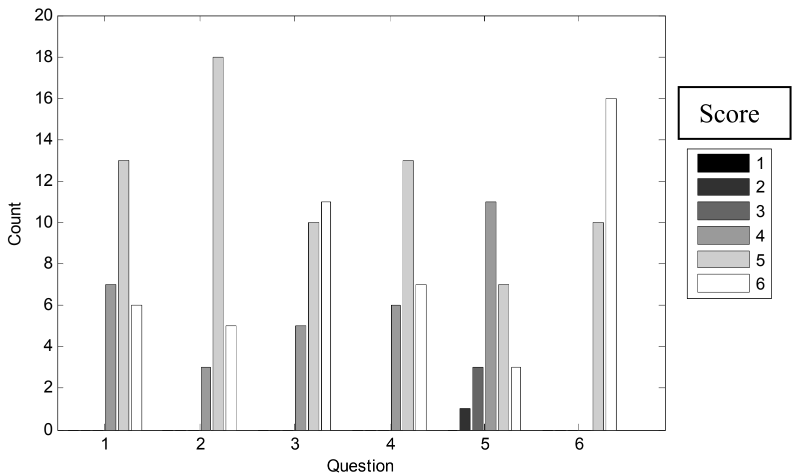

Fig. 6. Survey result

5 User Study

26 people were invited to use our system. They were asked to fill the questionnaire with the questions as shown in Table 3, The users rated the question from 1 to 6. The higher the score given by the user, the higher satisfaction they feel. Scores 1 to 3 (4 to 6) represents the users are dissatisfied (satisfied) with our system respectively.

Fig. 6 shows the result in a bar-chart. Most of the users are satisfied with our system. For the game contents, most of the users like the game style learning and difficulty design. For the learning propose, 80% users agree with the system that it can help people to identify the similar characters. For the performance of the searching, all the users are satisfied with the searching results. 70% of users are satisfied with the searching speed. In the aim of reducing workload of teacher, all users rated it with scores higher than 4.

6 Conclusion and Future Work

In this paper, we have proposed a game to help students distinguish similar Chinese characters and master the correct handwriting skill. The game contents are created automatically with our proposed approach in searching for similar characters using the character type information. The proposed framework can reduce the workload of teachers and encourage students learning Chinese with fun using games. As future work, we will enhance our approach to find more missing characters by exploring the similarity between radicals among different types to consider more potential similar candidates. Moreover, we will incorporate the relative spatial relationship in evaluating the similarity between two characters. Finally, we will develop other types of games to help students better understand the Chinese character formation and proper usage.

Acknowledgments

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Integrating Learning Styles and Personality Traits into an Affective Model to Support Learner's Learning

Makis Leontidis and Constantin Halatsis

Department of Informatics and Telecommunications, University of Athens
Panepistimiopolis, GR-15784 Athens, Greece
{leon,halatsis}@di.uoa.gr

Abstract. The aim of this paper is to present a model in order to integrate the learning style and the personality traits of a learner into an enhanced Affective Style which is stored in the learner's model. This model which can deal with the cognitive abilities as well as the affective preferences of the learner is called Learner Affective Model (LAM). The LAM is used to retain learner's knowledge and activities during his interaction with a Web-based learning environment and also to provide him with the appropriate pedagogical guidance. The proposed model makes use of an ontological approach in combination with the Bayesian Network model and contributes to the efficient management of the LAM in an Affective Module.

Keywords: User Modeling, Affective Computing, Affective Model, Ontology.

1 Introduction

Research in computer science has begun to take emotions into account, because their influence in perception, reasoning, decision-making and learning is considered catalytic. A new field, which is called affective computing [9] and is located in the scientific area in the intersection of artificial intelligence, cognitive psychology and physiology, has come to surface with the promise to offer a wide range of methods, techniques and applications which take into account affectivity. The affective issues remain today major concerns of the designers of affective machines. Especially in education, they constitute important factors and significant requirements for the accomplishment of learning goals.

The aim of this study is to present an integrated Affective Style which consists of the learning style and the traits of the learner's personality. This enhanced style relies on the combination of the Index of Learning Style (ILS) [3] with the Five Factor Model of personality [2] and is stored in the Learner Affective Model (LAM). The LAM can store the cognitive abilities and the affective preferences of the learner and is used to provide the learner with the appropriate pedagogical guidance. The proposed model also makes use of an ontological approach in combination with the Bayesian Network (BN) model and serves as a basis for the formal representation of the uncertain affective information. In this way it provides a machine-processible way

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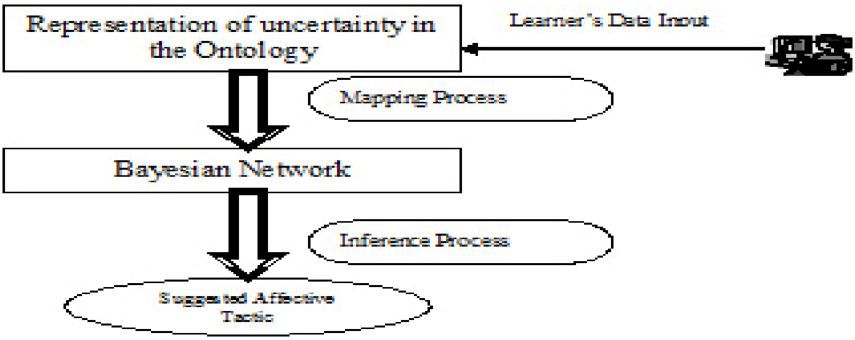

Fig. 1. The proposed model for the management of the Affective Information

to map respectively an ontological structure into a BN [6], supports the reasoning process and contributes to the efficient management of the LAM (figure 1). The LAM is located in an Affective Module, which is integrated in a Web-based Adaptive Educational System (WBAES). The foremost and endmost goal of this educational system which is named MENTOR, is to provide the learner with a more personalized and friendly environment for learning, according to his personality, mood and emotions. Adopting this perspective the Affective Module supports the personalized distance learning according to the learner's individual characteristics.

In this paper we first introduce the basic concepts of our framework which are related to learning styles, types of personality, Ontologies and Bayesian Networks (BNs). In the next section we present the architecture of the MENTOR's Affective Module which is designed for supporting personalized distance learning [7]. Then, in the forthcoming two sections the proposed method for the learner's affective modeling and the inference mechanism, based on the proposed model, for the selection of the appropriate affective tactic, are analyzed respectively. Finally, conclusions and future plan of our research are discussed.

2 Background and Basic Concepts

2.1 Learning Styles

Different learners have various preferences and needs, so they learn in different ways. Some of them prefer theories and principles, while others facts and experimentation. Some learners tend to remember things which employ pictures, diagrams or presentations whereas others learn better with written or spoken material such as text and auditory material. Consequently, it is vital to provide different type of learners with the appropriate learning method and educational material which are more preferable and more effective to their individual needs.

Learning styles can be defined as models which classify learners according to the different ways in which receive, organize and process information. Although, several models of learning styles have been proposed, in this study the Index of Learning

Style (ILS) which is proposed by Felder and Silverman [3] is adopted in order to model the learner from a cognitive point of view. The ILS classifies the learner based on five dimensions. Visual (V) / Verbal (B) in relation to the input of information, Sensory (S) / Intuitive (N)) in relation to the perception of information, Global (G) / Sequential (Q) in relation to the understanding process of information, Active (A) / Reflective (R) in relation to the processing of information and Inductive (I) / Deductive (D) in relation to the organization of information. In this paper we use the first four dimensions, because according to Felder and Silverman, most students are inductive learners.

Visual learners prefer to learn engaging images, graphics, and diagrams. Thus, the educational material must have content areas mainly led by images in order to help the learners of this type to establish an understanding of the learning contents. Verbal learners prefer to learn using written or auditory material. Therefore, the educational material must have a text-driven area which is led by written texts. Sensor learners prefer to learn by experiments and facts. They like detailed information but they are not in favour of complications. Thus, the educational material must have content areas mainly led by additional sources, examples and problems where they may help sensor learners to establish better perception of the learning contents. On the other hand Intuitive learners are in favour of complicated data but they do not like the detailed material. Thus, an appropriately formed material without detailed information must be presented to them.

Global learners prefer to have a “big picture” of a concept. Usually, they prefer to jump directly to the section in which they are interested in. They deal intuitively with a problem and come up frequently with a solution without to be capable of giving sufficient explanations for their approach. Thus, the educational material must be presented to them in a way where they have the ability to look over the big picture of the learning contents as well as to have easy access to every section. Conversely, Sequential learners follow a linear reasoning process when deal with an educational material or a problem. They prefer a sequential order to deal with it. Thus, an educational content which allow them to learn in a steady way and where the concepts are presented with a sequential order, is more suitable for this kind of learners.

Active learners prefer the active experimentation and in general tend to think less than they act. Therefore, an educational material which enables to express themselves freely by acting must be presented to this type of learners. On the contrary, Reflective learners tend to think more, process information reflectively and reconsider on the others’ opinion. From this point of view they may be considered more passive comparing to the Active learners. Thus, the presented educational material must provide them with the opportunity to think carefully on the concepts and tasks which it contains. According to the ILS we can model a learner in relation to what type of information prefers to perceive and process, which sensory channels employs more to receive the external information and which methods uses to organize better this information.

2.2 Personality and Five-Factor Model

The personality determines all those characteristics that distinguish one human being from another. It is related to its behaviour and mental processes and has a permanent character. The most known model of personality is the Five Factor Model (FFM) and results from the study of Costa and McCrae [2]. It is a descriptive model with five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

Due to these dimensions the model is also called OCEAN model. This model describes an Openness person as accessible to new experiences, creative, imaginative, intellectual, interested in culture, social, emotional aware, with a significant sense of freedom and exploration. According to the intensity of these characteristics a person who belongs to the Openness category is characterized either as Explorer, or as Moderate or as Preserver. Conscientiousness refers to a person who is well-organised, dutiful, responsible, persistent in achieving goals, thinking and planning in detail before acting, controlling his impulses, with consolidated points of view. According to the intensity of these characteristics, a person who belongs to the Conscientiousness category is characterized either as Focused, or as Balanced or as Flexible. Extroversion refers to a social, energetic, talkative person who is liable to make new acquaintances easily and to demonstrate positive emotional behaviour. According to the intensity of these characteristics a person who belongs to the Extroversion category is characterized either as Extrovert, or as Ambivalent or as Introvert. Agreeableness refers to a person who is cooperative, modest, friendly, accommodating, trusting, positive motivated in his interactions with other people and lucks antagonistic intentions. According to the intensity of these characteristics a person who belongs to the Agreeableness category is characterized either as Adapter, or as Negotiator or as Challenger. Finally, a negative emotionality is predominant in a Neuroticism person, so this person usually feels nervous, anxious, in pressure, insecure, emotionally unstable and prone to pessimist thoughts. According to the intensity of these characteristics a person who belongs to the Neuroticism category is characterized either as Reactive, or as Responsive or as Resilient. The descriptive character of FFM and the particular characteristics that accompany each type of personality (traits) allow us to model the learner's personality and use this information in educational applications [1]. The FFM provides us with a reliable way in order to connect a learner's personality with his mood and emotions that he possibly develops during the learning process. This is very useful because we are able to initiate a learner's emotional state and select the suitable pedagogical strategy.

2.3 Ontologies and Bayesian Networks

Ontology is a formal way to represent the specific knowledge of a domain, describing formally and explicitly its vocabulary in terms of concepts, classes, instances, relations, axioms, constraints and inference rules. Ontologies represent knowledge in taxonomies, where more specific concepts inherit the properties of those concepts which they specialize [10]. Therefore, an Ontology expresses a common understanding of a specific domain that serves as a formal platform for efficient exchange of data between information systems. We exploit the advantages of ontological representation in our model to set the vocabulary, properties, and relationships for learning and pedagogical concepts under an affective perspective, the result of which can be a set of rich schemas.

Taking advantage of the above benefits, we use an Ontology of emotions and affective tactics in order to achieve a formal and proper representation of the LAM and the system's learning strategies. In this way we are capable to reason and infer efficiently with the affective factors which occur during the learning process. The structure of the proposed Ontology is in compliance with the OCC emotions classification as well as the OCEAN model of personality and has been adjusted suitably in order to attain the requiring knowledge and the pedagogical representation for our educational system. This Ontology, which is an application–domain Ontology, contains the necessary affective information to model and support specifically the educational operations of the MENTOR.

Bayesian Networks are graphs the nodes of which depict random values and the arcs the correlations between independent assumptions [5]. More specifically a BN is a Directed Acyclic Graph, or DAG, that is a structure that has no directed cycles. A set of random variables makes up the nodes of the network. Directed arcs connect pairs of nodes. The meaning of an arc from node X to node Y is that X has a direct influence on Y. The uncertainty of the relationship of each node is represented by the Conditional Probability Table (CPT). The CPT presents the probability that a child node is assigned to a certain value for each combination of possible values of its parent nodes. The parents of a node are all those nodes that have arcs pointing to it. In this manner the CPT quantifies the effects that the parents have on the node. We denote as $P(X_i \mid Parents(X_i))$ the probability that is associated with each node X_i, where $Parents(X_i)$ is the parent set of X_i. Then we can calculate the joint probability distribution of X_i under the conditional independence assumption make use of the formula:$P(X) = \prod_i P(X_i \mid Parents(X_i))$, $i=1, 2,\ldots,n$.

Bayesian networks have been successfully used to model knowledge under conditions of uncertainty within Intelligent Tutoring and Adaptive Educational Systems [12]. Also, methods have been developed from data combination and expert system knowledge in order to train these systems. In this way an information system can easily process the knowledge which is encoded formally in a BN representation. Thus, making use of BNs, we can handle efficiently conditions of uncertainty and facilitate human understanding with computational models which can perform effectively actions of reasoning and inference.

Because of the nature of BNs we can define the concepts of our Ontology as the variable nodes of the BN and the arcs between them as the probabilities which influence their relation. Under this perspective we can reliably estimate how the initial probabilities affect uncertain cases such as the suitable selection of the affective tactic and the future behavior of the learner after the adoption of this tactic. Consequently, we exploit the advantages of the BNs in order to make predictions in relation to the support of the pedagogical development of the learner during his learning process.

3 The Architecture of MENTOR's Affective Module

The MENTOR's Affective Module aims to recognize the emotions of the learner during his interaction within an educational environment and thereafter to provide him with a suitable learning strategy [7]. The operation of the Affective Module is based on the FFM [2] and the OCC model [8]. The module is being attached to the

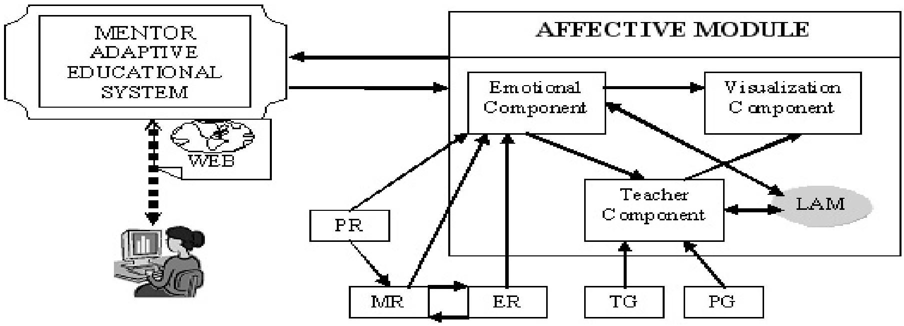

Fig. 2. The basic architecture of MENTOR's Affective Module

MENTOR providing the system with the essential "emotional" information in order to determine the strategy of learning in collaboration with the cognitive information.

The architecture of MENTOR is presented in figure 2. The MENTOR's Affective Module has three main components: The Emotional Component (EC), the Teacher Component (TC) and the Visualization Component (VC), which are respectively responsible for: a) the recognition of learner's personality (PR), mood (MR) and emotions (ER) during the learning process, b) the selection of the suitable teaching and pedagogical strategy and c) the appropriate visualization of the educational environment. The combined function of these components "feeds" the educational system with the affective dimension optimizing the effectiveness of the learning process and enhancing the personalized teaching. The main purpose of MENTOR is to create the appropriate learning environment for the learner, taking into account particular affective factors in combination with cognitive abilities of the learner offering in this way personalized learning.

The architecture of the MENTOR is designed with equal respect to the cognitive and the emotional dimension of teaching as well. So, we consider that the Teacher Component which is in charge of the formation of teaching consists of two subcomponents, the Teaching Generator (TG) and the Pedagogical Generator (PG) which are responsible for providing the cognitive and emotional tactic respectively. Therefore, we use the term affective tactic so as to denote that the learning method which is suggested by the Teacher Component is a two-dimensional combination of cognitive and emotional guidance and support [7].

4 Modeling Learner's Behavior with an Affective Model

Considering the learner's individual traits both of his learning style and personality type, we construct an integrated style which is called Affective Style. Thus, we model the learner according to his cognitive abilities and his emotional idiosyncrasy, as well. The proposed Affective Style has five dimensions which are: The four dimensions of the ILS and one more in relation to the OCEAN model. Therefore, taking advantage of this style a learner can be described based on a cognitive aspect in combination to an idiosyncratic one. For example, a learner who prefers to acquire the information via pictures, perceives it in an experimental way, processes it actively through engagement in activities, understands it in continual steps and demonstrates a creative or explorative tendency can be classified, based on the proposed Affective Style, as a Visual, Sensor, Active, Sequential and Openness or VSAQO learner. Therefore, in relation to this style a learner can be provided with the appropriate educational material and the suitable affective tactic via a dynamic adaptive user interface.

This Affective Style is incorporated in the LAM with an ontological approach. The Affective Style of the learner is defined by means of a suitable dialogue which is selected and presented by the MENTOR when the learner uses the system for the first time. This dialogue is based on the Index of Learning Style Questionnaire (ILSQ) [11] as well as the Goldberg's questionnaire [4]. The LAM stores the system's knowledge about the learner, such as general information about him, his Affective Style, his current emotional state, his knowledge level and his learning goals. It reflects the learner's individual characteristics and also tracks how well he performs on the material which is being taught while supports his interaction with the MENTOR. Consequently, the adaptation of MENTOR relies decisively on the LAM which stores the affective and all the relevant information about the learner.

The model which is proposed in this paper is based on the combination of two different technological approaches. The first adopts an ontological approach so that the representation of the learner's affective information can be achieved. The second uses the BN model in order to validate the initial predicted learner's Affective Style and select the most appropriate affective tactic according to this style with the aim of fitting better to his particular needs. In this way an Ontology-based BN it is formed [6], which stores the affective information of MENTOR, the acyclic graph, the data set of the implicit evidence and the transitions between the educational situations.

Taking advantage of the above method, we use this Ontology-based BN in order to achieve a formal and proper representation of the LAM and to reason and infer

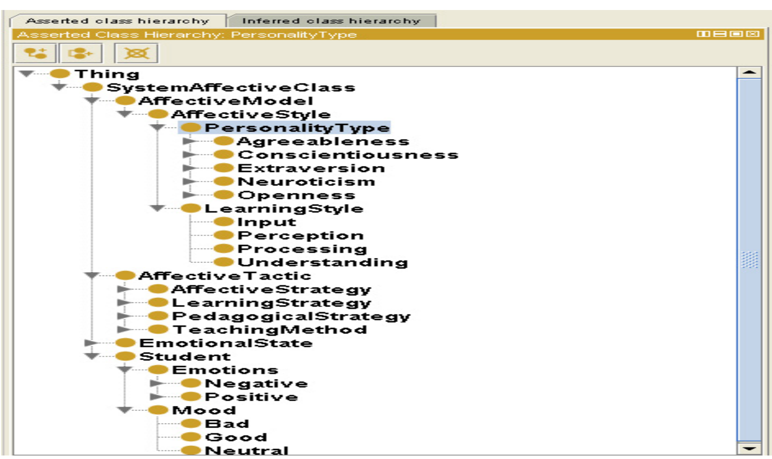

Fig. 3. An Excerpt from the Affective Ontology of MENTOR

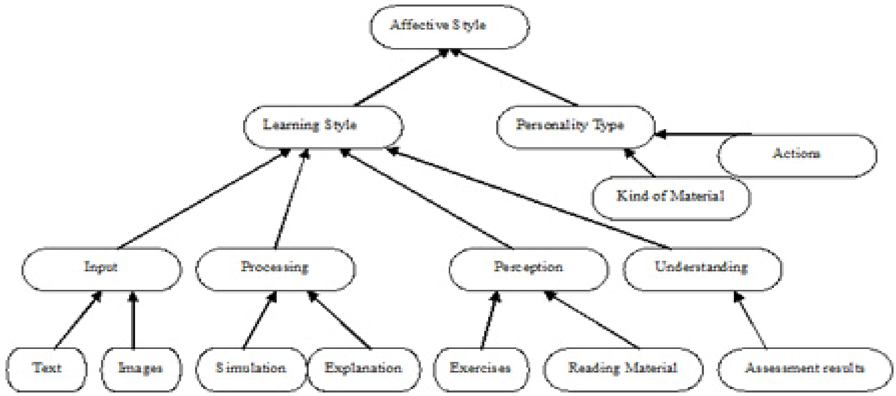

Fig. 4. The Bayesian Network which models a Learner's Affective Style

efficiently with the affective factors which occur during the learning process. The Ontology is called Affective Ontology because it stores and deals with affective information such as the affective tactics, learner's affective model and his emotional state. Consequently, in order to represent the affective information in the Ontology, the creation of the relative classes is necessary. Thus, the Affective_Model Class, Affective_Tactic Class and Emotional_State Class, are constructed (figure 3).

In order to construct the BN we need to determine the significant variables and their status as well. So, we build the acyclic graph which contains the variables of interest and the relationships between them. In the next step in order to identify the strength of the modelled relationships, we assign the probability distribution to each node in the graph. In MENTOR's application domain the variables of interesting in relation to the LAM are the Affective Style and its five different dimensions. So, we represent each dimension with a variable in the BN. The values which these variables can take are: visual / verbal, sensory / intuitive, active / reflective, global / sequential and openness / conscientiousness / extraversion / agreeableness / neuroticism, respectively. A part of the BN is shown in figure 4.

According to these variables we model the learner's interaction with MENTOR based on relative attributes to the system's educational events. Analyzing further these attributes we can classify the learner. For instance, to identify whether a learner is a Visual or a Verbal, we determine the type of presented material which prefers to study (images or text), while to discover if he is a Sensor or an Intuitive we ascertain the type of educational material which prefers to read (abstract or concrete). In the same way to decide on the type of Personality he belongs to, we find out the kind of the learning material (theory, problems, examples, exercises), which fits better to him. This information is provided by analyzing the data recorded in the learner's log file.

5 Providing the Learner with the Appropriate Affective Tactic

Based on the proposed affective model and taking advantage of the significant probabilistic features of the BNs which enable us to reason and make inferences in an efficient way, we can provide the learner with the appropriate pedagogical guidance.

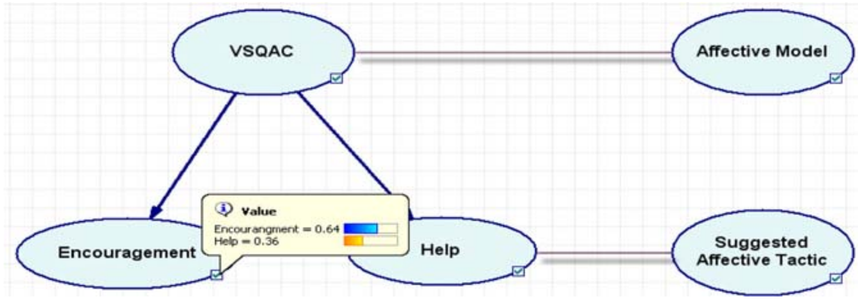

Fig. 5. An example of the Affective Tactic's selection process

The probabilistic inference considers a set S of propositional variables S_i, i=1,…,n and the evidence that the variables in a subset U of S have definite values, U_i= u. (True or false). Then the conditional probability, that a variable S_i has value s given the evidence is calculated by the type: $P(S_i \mid U_i) \times P(U_i) =. P(U_i \mid S_i) \times P(S_i)$.

In our model we use an Ontology-based BN approach to represent the affective information of MENTOR [6], in order to deal effectively with the uncertain factors which occur during the learning process such as learner's emotions and mood. All this information is stored in the LAM in order to provide the learner with a suitable affective tactic and to engage him effectively into the learning process. The main reason for using the BN model in our method is that allows us to infer easily the uncertain values of the nodes in relation to the affective information of the learner's model, as shown in figure 5. This model supplies us with evidences for selecting the appropriate affective tactic, given the values of the affective model node. As a result, calculating the posterior probability which a certain affective tactic has a given value we infer that the suitable is the one having the greatest probability value.

Let us examine, for example, the case of a learner whose Affective Style is VSQAC and fails to accomplish a given task. Then negative emotions such as sadness or disappointment can appear. He seems to be less confident in the current session and there is the danger of giving up the trial. He fears maybe that he has not got the ability to deal with a project that was assigned to him and he will not live up to his teacher's expectations. According to the proposed model, there are pedagogical actions which can be applied in order to eliminate the learner's negative emotions. For instance, the system may give him help or encourage him to try again. In this way, the learner has great chances to resolve the problem, so that his confidence would be regained and positive emotions such as happiness or satisfaction can preserve an upbeat to the learner's mood.

6 Conclusions and Further Research

In this paper we introduced the Affective Style which consists of the learning style as well as the personality traits of the learner. This enhanced style relies on the combination of the Index of Learning Style (ILS) with the Five Factor Model of personality and is stored in the Learner Affective Model (LAM). The LAM can store the cognitive abilities and the affective preferences of the learner and is used to provide the learner with the appropriate pedagogical guidance. The LAM is located in an Affective Module, which is integrated in MENTOR. MENTOR is a WBAES for personalized distance learning. The main purpose of the MENTOR is to create and / or preserve a positive mood in the learner, since this is a crucial factor for the learning process. The proposed model also makes use of an ontological approach in combination with the Bayesian Network model in order to deal efficiently with the formal representation of the uncertain affective information.

Some preliminary experimental results are very encouraging for the further development of our proposed model. The Affective Module of MENTOR classifies appropriately the learner into the appropriate Affective Style so that he obtains the most suitable affective tactic. In advance research we plan to keep running an extensive experimental study conducting a web evaluation in order to testify more precisely the reliability of the proposed model. In this way the accuracy of our system will be improved in order to be capable of supporting the learner with more suitable affective tactics.

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A Three-Tier Profiling Framework for Adaptive e-Learning

Frederick W.B. Li[1], Rynson W.H. Lau[2], and Parthiban Dharmendran[1]

[1] Department of Computer Science, University of Durham, United Kingdom
[2] Department of Computer Science, City University of Hong Kong, Hong Kong

Abstract. Existing methods support adaptive e-learning mainly by setting student characteristics in a student profile, and use it as a filter to extract suitable learning content from a dedicated structure of course materials. If simple student characteristics, such as prior knowledge and learning preference, are considered, it may be straightforward for an instructor to set up the student profiles. However, if complicated student characteristics, such as learning styles, interaction styles and content styles, and other factors that affect the students' interests on the course materials are involved, it may become too difficult for an instructor to design a suitable course structure matching all these criteria. It is also complicated for system implementation as many rules need to be set up. In this paper, we propose a three-tier profiling framework in conjunction with a *concept space* structure and a set of *concept filters* to address the above problems. The framework offers a unified way to model and handle a variety of student learning needs and the different factors that affect course material relevance. The framework is extensible in nature and can form the foundation for the future development of adaptive e-learning systems.

Keywords: Profiling, student profiles, course profiles, adaptive e-Learning.

1 Introduction

e-Learning is a technology supported learning method. It allows students to learn at any time and place under the assistance of communication and multimedia technologies [Li08]. This facilitates an e-learning user to have virtually unlimited access to knowledge and to improve learning through multi-modality materials. On top of this, user profiling can be added to capture user characteristics, such as learning preference, background knowledge and learning progress, to help generate tailor-made learning materials and support adaptive e-learning.

The requirements of adaptive e-learning can be revealed through both the *learning process* and the *learning content*. A learning process is driven by "what to learn", i.e., the scope of learning, and "how to learn", i.e., how a student approaches such learning scope. Adaptive e-learning offers a student with tailor-made answers to these two questions. [Brus98, Midd04] support this by user profiling and course material organization, where the "what to learn" problem is addressed by filtering a set of course materials against user characteristics. The "how to learn" problem has

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two aspects: the psychological features of a student [Feld88], which leads the student to learn a set of contents through different sequences and abstraction levels, and the content style, which concerns choosing suitable types of course materials that match the student's prior knowledge. Learning content comprises a set of "concepts". To facilitate the identification of relevant concepts for fulfilling certain learning purpose, a set of concepts may be arranged in a hierarchical structure [Brus98]. In addition, ontology [Stud98] can be applied to formulate the grouping and the relation among concepts [Midd04] to offer semantically more accurate results. On the other hand, the relevance of a concept may also be dynamically influenced by some external factors, such as popularity, maturity, stability, features and innovativeness of the subject materials [Yue04].

To tackle the complicated requirements in supporting adaptive e-learning, we have developed a three-tier profiling framework. The framework comprises student, course and resource profiles, which are formulated in a unified way based on a novel *concept space* structure and a set of *concept filters*. The framework includes several levels of profiles instead of a single user profile, as we have found that certain adaptive e-learning criteria are not merely related to a single student and in fact many of them are mainly course related. The rest of this paper is organized as follows. Section 2 gives a survey on related work. Section 3 lays out the foundation and the usage of the proposed framework. Section 4 shows some experiments and discusses the results. Section 5 briefly concludes the paper.

2 Related Work

Existing solutions to the adaptive e-Learning mainly focus on applying student profiles on well organized courseware. A student profile captures the learning preference, background knowledge/experience and learning progress of students, which form the basis for filtering a pool of course materials to pick out relevant ones. For instance, InterBook [Brus98] utilizes a hierarchical structure along with indices to organize course materials according to the topics and level of difficulties, and applies student profiles to govern the course material selection. Alternatively, [Midd04] improves the discovery of relevant course materials by considering both the knowledge classification based on ontology and the collaborative choices made from a group of students. The ontology [Stud98] formulates the grouping and the relation among concepts. It is commonly applied to organize course materials and to form the metric for determining the student required materials. A further example can be found in [Dolo04]. The utilization of collaborative information [Bala97] can enhance the accuracy of the retrieved course materials, as it complements the incompleteness or impreciseness of individual user profiles. Recently [Frey07] has exploited user browsing and searching patterns to give more precise modeling on collaborative information. The above methods essentially addressed the "what to learn" problem.

The "how to learn" problem is also crucial to adaptive e-learning. Recently, student learning style [Feld88] in terms of psychological features, such as sequential, global, active and reflective, has been considered to address this problem. The implication of learning style is that a student may need to perform different tasks or follow learning materials in a different sequence and abstraction level in order to understand a piece of concept. [Papa03] applies learning style to allow a student to learn a concept through a different interaction style, such as a theory-oriented, exercise-oriented or activity-oriented one. [Schi08] proposes ways to acquire and understand the learning style of a student. Unfortunately, existing works pay little attention on the content style, as mentioned in the introduction section.

On the other hand, the dynamic nature of course material relevance and the reference material exploration have still not been well addressed. More specifically, the relevance of course materials is not solely determined by the needs of an individual student or an entire cohort, but also by some other factors [Yue04], such as the popularity, maturity, stability, features and innovativeness of course materials. Particularly, these factors are dynamic in nature. Besides such an issue, students usually learn more independently in an e-learning environment and use Web searching as a crucial means for problem solving and further exploration. The main concern here is a student's ability to identify relevant reference materials. Undeniably, PageRank [Page98] is the most popular solution to this searching problem, which determines the importance of a Web page from the hyper-link structure among Web pages. [Qiu06] extends PageRank by generating topic specific rankings to each Web page and allows matching such rankings against user profiles to offer tailor-made searching results. This partially addresses the reference material exploration problem in adaptive e-learning. However, although both the student learning style and the relevance of course materials due to external factors [Yue04] play crucial roles to the suitability of the reference materials, they have not been properly addressed.

3 Foundation

3.1 Framework Overview

Our research on adaptive e-learning leads to a very interesting finding. Existing work supports adaptive e-learning mainly through student-profiling, which requires a dedicated course material structure. However, we find that many important parameters that support adaptive e-learning, such as different aspects of learning styles, cohort learning preference and course content related factors, are in fact not directly related to the student profiles, but should be defined together with individual courses. Hence, we propose a three-tier profiling framework, as shown in Figure 1, to address this problem.

The framework comprises student, course and resource profiles. The student profile formulates the student learning needs. The course profile maintains the course structure according to major subject topics and gives definition on how a student can learn the course regarding a variety of learning, content and interaction styles. The resource profile maintains needs from students, course and external environment regarding the concepts/terminologies under subject topics to help students identify well-fit learning resources. Although the information maintained in the three types of profiles are significantly different, we find that the information within each profile can be categorized into *learning scope* and *selection criteria* for defining "what to learn" and the ways to determine it. In our framework, we use a *concept space* structure and a *concept filter set* to formulate these two types of information.

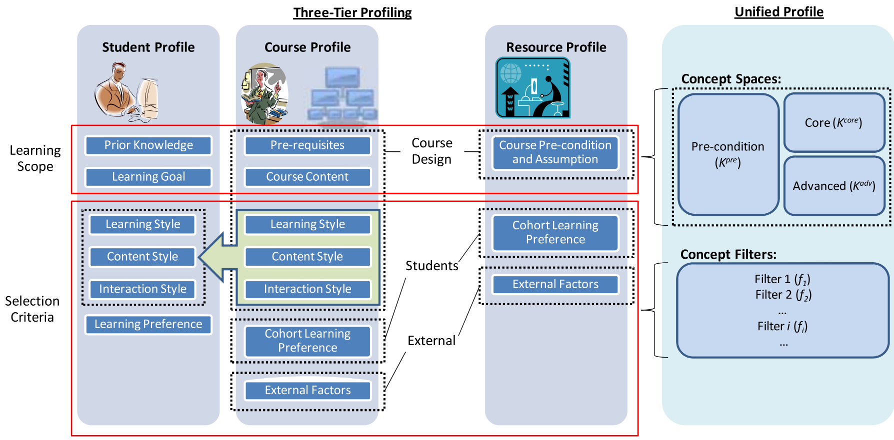

Fig. 1. Conceptual model of the three-tier profiling framework

3.2 Unified Profile Structure

As shown in Figure 2, we formulate student, course and resource profiles using a *unified profile* structure. The unified profile constitutes three *concept spaces*, namely the pre-condition K^{pre}, core K^{core} and advanced K^{adv} concept spaces, and a *concept filter set* F. Each of the concept spaces is modeled as a collection of *concept nodes*, which will be discussed in Section 3.3. K^{pre} defines the prior requirements before tailor-made learning content can be determined, while K^{core} and K^{adv} define the core and the advanced learning contents. The concept filter set F is used to modify a concept space through adjusting the importance and the level of abstraction of each concept node inside the concept space.

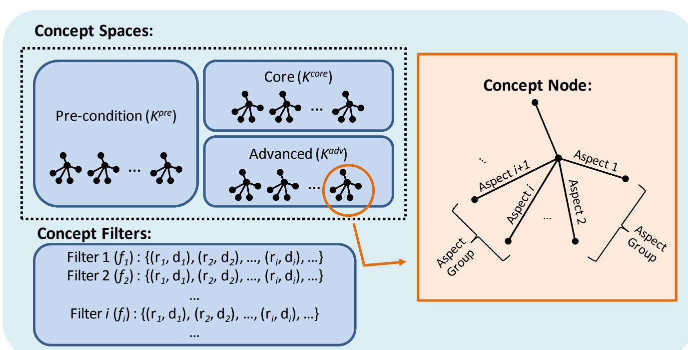

Fig. 2. The unified profile structure

Given the unified profile structure, to construct a *student profile*, K^{pre} defines the prior knowledge or experience of a student, while K^{core} and K^{adv} give the core and advanced learning goals of the student in a course context. The concept filter set F handles the course specific learning preference and a variety of learning, content and interaction styles. Note that only preferences of these styles are stored in the student profile. Their actual filter definitions are stored in the course profile. In a *course profile*, K^{pre} defines the pre-requisite or the entrance requirement of the course, while K^{core} and K^{adv} define the core and advanced learning scopes of the course. The concept filter set F includes learning style [Feld88], content style and interaction style [Papa03] filters to define how the course content can match with these styles. It also includes filters to describe the collaborative learning preference of a cohort. In addition, it has filters to define the importance or relevance of each piece of course content against the external factors. The *resource profile* focuses on modeling the course specific assumptions or pre-conditions. It is done by giving definitions to the course specific terminologies and formulates the relationship among them. In particular, K^{pre} defines the set of concept for exclusion, while K^{core} and K^{adv} give the core and the advanced concept definitions and relationships. For instance, one can define the course related synonym and the polysemy in a resource profile. The concept filter set F here includes filters to take care of the cohort learning preference and the external factors that affect the concept relevance of the course. The difference between a course profile and a resource profile is that a course profile focuses on modeling the relation among major subject topics, while a resource profile focuses more on modeling the course specific terminologies. With the resource profile in place, when a student performs a Web searching to seek for reference materials, his/her query may be refined by the resource profile to help obtain better fit results, which match the course context.

3.3 Concept Space

A *concept space* K is defined as a confined set of knowledge. As shown in Figure 2, it is modeled as a collection of *concept nodes* k_n, where each k_n represents a small piece of knowledge and is uniquely identified with an index *n*. A concept node k_n is modeled as a multi-dimensional space, where each dimension refers to an *aspect* of the knowledge that k_n represents. The aspects can be defined based on ontology or the expertise of a course designer. Each aspect of a concept node attaches two indicators, namely an *aspect weight* and a *level of abstraction*, which are defined with a scale from 0 to 1. The aspect weight indicates the importance / relevance of an aspect, while the level of abstraction describes how detailed the corresponding learning materials of an aspect should be released. In addition, *aspect groups* can be set up to group related aspects. We have three aspect groups in our current implementation, namely the *interaction style group*, *content style group* and the *polysemy group*, which handle the learning activities, learning approaches and the multiple meanings of a concept, respectively. We allow a course designer to define a course using concept spaces rather than through constructing a complicated ontology hierarchy. Such arrangement greatly simplifies the process of creating an adaptive e-learning course and makes it possible for the general instructors to create adaptive e-learning courses.

3.4 Concept Filter

Concept node filtering is a mechanism to shape a concept space to commit certain needs. A concept filter comprises filters at all different concept node levels, i.e., *concept*, *aspect group* and *aspect* levels. All types of filters are formulated in the same way as a list of (r_i, d_i)-pair, where r_i and d_i are the weight for adjusting the importance and the abstraction level of an elements at a concept node level, respectively, and both of them are defined with a scale from 0 to 1. The (0, 0)-pair means that the corresponding element should be ignored. More specifically, the setting of importance values natively indicates the presentation order of each element at a concept node level, while the abstraction level defines the degree of detail of the course material associated with the element to be present to a student. In our implementation, we use concept filter to formulate the individual / collaborative learning preference, the learning / content / interaction styles and the external factors that determine the course material relevance. However, the concept filter is not limited to these usages. Any learning need that requires presenting learning materials with a preferred order or abstraction level may also be modeled using a concept filter.

3.5 Usage

From the student perspective, under our framework, when a student wants to enroll a course, his/her profile will be checked against the course profile to verify his/her eligibility. This is done by the concept node comparison. Once the study right is granted, a set of selection criteria (formulated using concept filters) from both the student and the course profiles will be applied to generate an adaptive learning scope for the student, which will be saved to become the student's learning goal (formulated using concept nodes). Note that a course designer may define the importance of each selection criteria to meet the purpose of the course. The definitions of the learning, content and interaction styles (formulated using concept filters) are course specific and are defined alongside the course profile; a student profile only maintains a list of preferences of the relevant styles to match with the ones in the course profile. We will discuss the design and usages of the concept filters through the examples in Section 4. If a student needs to search for learning resources from the Web, the search query can be refined by applying the resource profile to obtain more course relevant results.

From the course design perspective, the course designer should divide a course into several subject topic groups (formulated using concept node aspects). For example, a Web technology course may be divided into three groups: 1) Web site construction, 2) content management and layout design and 3) data management for dynamic Web applications. Each group can then be further divided into different subject topics. For example, the content management and layout design group can be divided into content management system (CMS), layout design applications, CSS programming, etc.. The CMS and layout design applications can be disseminated with a non-programming approach (formulated using aspect group); we refer to this as a "content style". In contrast, CSS programming can be arranged to disseminate with a programming oriented approach. In short, the subject topic groups, the individual subject topics and the content styles are formulated using the *concept nodes*, *concept node aspects* and *aspect groups* under the unified profile structure.

4 Experiments and Discussions

We have conducted a set of experiments to demonstrate the generation of adaptive courses to different students based on their characteristics. The experiments were conducted on the "Web Technologies" course offered to 25 students. The students had a bachelor degree in either computer science (CS students) or another discipline (non-CS students). Their profiles are shown in Tables 1 and 2.

Table 1. Profiles of the non-CS students

Concept Space	Students																	
Prior Knowledge	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S 10**	**S 11**	**S 12**	**S 13**	**S 14**	**S 15**	**S 16**	**S 17**	**S 18**
Content management systems [CMS] (**A1.1**)	0	0	0	0	0	0	0.4	0	0	0.4	0.6	0	0	0	0	0	0	0
Layout design application (**A1.2**)	0.2	0.2	0	0	0	0	0.6	0	0	0.6	0.6	0	0	0	0.4	0	0	0.2
CSS Programming (**A1.3**)	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0.2
Webpage Basics [HTML] (**A2.1**)	0.2	0.2	0	0	0	0	0.2	0.4	0	0.2	0.2	0	0.2	0	0.2	0	0	0.2
Web site building tools [Dream weaver] (**A2.2**)	0.2	0.4	0	0	0	0	0.4	0	0	0.4	0.4	0	0	0	0.4	0	0	0.4
Web Applications - Ruby on Rails (**A2.3**)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MS Access Database (**A3.1**)	0.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0.6
MySQL Database (**A3.2**)	0	0	0	0	0	0	0	0.6	0	0	0	0	0.6	0	0	0	0	0
Learning Style																		
Sequential		✓	✓	✓	✓	✓	✓											
Global	✓							✓								✓		
Sensory									✓	✓	✓	✓	✓	✓	✓		✓	✓
Learning Preference		A 2.2					A 1.1		A 3.1	A 1.1								

Table 2. Profiles of the CS students

Concept Space	Students						
Prior Knowledge	**S19**	**S20**	**S21**	**S22**	**S23**	**S24**	**S25**
Content management systems [CMS] (**A1.1**)	0.2	0.4	0	0	0	0	0.2
Layout design application (**A1.2**)	0.2	0.4	0	0	0	0	0.2
CSS Programming (**A1.3**)	0.2	0.2	0.4	0.6	0.2	0.4	0.2
Webpage Basics [HTML] (**A2.1**)	0.6	0.4	0.4	0.4	0.4	0.4	0.6
Web site building tools[Dream weaver] (**A2.2**)	0.2	0.2	0	0	0	0	0.2
Web Applications - Ruby on Rails (**A2.3**)	0.6	0.4	0.4	0.6	0.6	0.6	0.6
MS Access Database (**A3.1**)	0	0	0.4	0.6	0.2	0.4	0
MySQL Database (**A3.2**)	0	0	0.2	0.4	0.2	0.4	0
Learning Style							
Sequential	✓	✓	✓	✓			
Global							
Sensory					✓	✓	✓
Learning Preference	A1.1					A1.2	

The profiles describe the students' course relevant *prior knowledge*, *learning style* indicating their intrinsic and psychological features, and *learning preference* indicating their favor topics of the course. The course design as shown in table 3 is set by the course instructor. The design is defined by giving out definitions to the core and advanced concept nodes, the aspect groups and the aspects of each concept node, and the aspect weight and the level of abstraction of each aspect. Note that the aspect group is set up based on the *programming* and the *non-programming* types of content styles to indicate the approach that a course aspect will be disseminated to students. As we want to demonstrate the flexibility of our framework rather than illustrating a fixed example scenario, we will show experimental results and discussions in a way that the design and the usages of the concept filters can be revealed.

Table 3. The course design of the Web technology course

Aspect Group	Course Content		Aspect weight	Level of abstraction
	Content management and layout design (Concept node 1)			
Non-programming	Content management systems [CMS] **(Aspect 1.1)**	Core	0.8	0.8
		Advanced	0.8	0.4
	Layout design application **(Aspect 1.2)**	Core	0.4	0.6
		Advanced	0.4	0.4
Programming	CSS Programming **(Aspect 1.3)**	Core	0.8	0.6
		Advanced	0.8	0.4
	Web site construction (Concept node 2)			
Non-programming	Webpage Basics [HTML] **(Aspect 2.1)**	Core	0.8	0.8
		Advanced	0.6	0.4
	Web site building tools [Dream weaver] **(Aspect 2.2)**	Core	0.8	0.8
		Advanced	0.8	0.6
Programming	Web Applications - Ruby on Rails **(Aspect 2.3)**	Core	0.6	0.6
		Advanced	0.6	0.2
	Data management for dynamic Web applications (Concept node 3)			
Non-programming	MS Access Database **(Aspect 3.1)**	Core	0.4	0.6
		Advanced	0.6	0.4
Programming	MySQL Database **(Aspect 3.2)**	Core	0.6	0.8
		Advanced	0.4	0.2

The prior knowledge of each student on a course aspect is described with a scale from 0 (no knowledge) to 1 (perfect knowledge). We have found that 28% of the students had an above average knowledge level (>=0.6) in some aspects of the *programming* type of the course content, while the rest of the students had an average or lower knowledge level. In addition, 56% of the students had no knowledge in all course content. To apply the students' prior knowledge, a student was exempted from studying the core part of course aspect(s) if he/she had already obtained an above average knowledge level. For example, students S19 and S25 were exempted from studying the core part of Webpage Basics [HTML] (A2.1), but still needed to take the advanced part of it.

Content Style: The idea of the concept filter is an important feature of our framework. In this part of the experiment, we set up content style filters as concept filters at the aspect group (AG) level. The format of the filters is shown in Figure 3.

To test with the content style, we set up content style filters as follows for both the *non-programming* and *programming* type of the course content to help deliver appropriate course content to the non-CS and the CS students, respectively.

Non-Programming Core Filter: {(1, 1), (1, 0.4), (1, 1), (0, 0), (1, 1), (1, 0.2)}
Non-Programming Advanced Filter: {(1, 1), (0, 0), (1, 1), (0, 0), (1, 1), (0, 0)}
Programming Core Filter: {(1, 0.2), (1, 1), (1, 0.2), (1, 1), (1, 0), (1, 1)}
Programming Advanced Filter: {(1, 0.6), (1, 1), (1, 0.6), (1, 1), (1, 0.2), (1, 1)}

The values of the *aspect weight* and the *level of abstraction* in the filters are multiplied to the corresponding values of appropriate concept aspects. For example, the

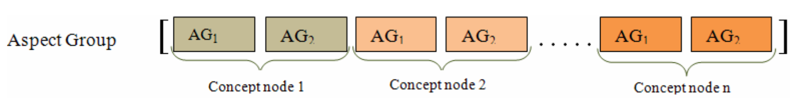

Fig. 3. The format of the content style filters

second value-pair of the non-programming core filter is applied to multiply against that of the concept aspect A1.3, which gives (0.8, 0.24) as the result. This means that the non-CS students still need to study some concept in CSS programming, but it will be disseminated in a very low level of details, such as introducing students with CSS programming based on simple examples. In addition, as the corresponding value-pair of the non-programming advanced filter have a (0, 0)-pair, no advanced content on CSS programming is delivered to the non-CS students. As a summary, content style filter provides a straightforward and easy way for an instructor to well control what type of content should be delivered to certain type of students, and how detailed such content should be disseminated.

Learning Style: We have conducted experiments with three different kinds of learning style filters, namely the *global*, *sequential* and *sensory* filters. Students with the global learning style can understand a subject much easier by studying some high level concepts to get an overview of the subject first before going into the details. Students with the sequential learning style need to finish a topic before they begin another one. Students with the sensory learning style can understand a subject much easier by studying much more details and concrete examples on a concept. The setting and usage of the learning style filters are quite different from the content style filters. Here, the filters are applied to control what to disseminate to the students during a learning process in a course, while the content style filters are applied only at the initial stage of the students' learning process to confine the scope of the study. Hence, each type of learning style filters actually comprises a set of filters that may be applied over different learning stages of a student.

To set the *global learning style filters*, we initially assigned smaller values in all level-of-abstraction items. After a student finished a learning stage, we applied another global filter with larger values in the level-of-abstraction items. The subsequent global filters were set in the same way until all level-of-abstraction items equal to 1 or certain desired value. To set the *sequential learning style filters*, we utilized the aspect weight as a control to allow only one course aspect to be delivered at one time. For example, if we want to disseminate Webpage Basics [HTML] (A2.1) initially, we use this sequential learning style filter (at concept aspect level): {(0, 0), (0, 0), (0, 0), (1, 1), (0, 0), (0, 0), (0, 0), (0, 0)}. The level of abstraction is not a determinant factor in this filter and can be set as 1. To set the *sensory learning style filters*, we may set it in the same way as the sequential learning style filters as long as the level of abstraction is set to 1, since the emphasis here is on disseminating detailed course materials. Of course, given that the learning style filters are easy to set, a course designer is free to set appropriate values to the filters based on his/her expertise to give a better course dissemination.

Learning Preference: Unlike learning style, learning preference emphasizes more on the student's choice rather than focuses on the intrinsic or psychological features of a student. In our experiment, we allow students to make a choice on a favorite course aspect. The filter setting is quite straightforward. We put a larger value on both the aspect weight and the level of abstraction to help disseminate more material on the chosen course aspect for a student. However, considering that the course duration or the study hours of a student may be fixed, the filter should also be set to lower the values of the level of abstractions on some less important course aspects, i.e., those course aspects with a smaller value in the aspect weight.

5 Conclusion

In this paper, we have proposed a three-tier profiling framework, which comprises the *concept space* structure and the *concept filters*. It offers a unified way for modeling and handling a variety of student learning needs and the different factors that affect course material relevance. In our framework, we model course content using concept nodes instead of relying on the construction of complicated ontology hierarchies, since the concept node is much simpler for general instructors to construct their courses. More importantly, the framework has an extensible nature, as the concept node structure, the aspect and its group and the concept filter can be treated as building blocks and tools to model further learning needs. Hence, it can form the foundation for the future development of adaptive e-learning systems.

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Sharing Good Practice through Mash-Up Personal Learning Environments

Felix Mödritscher[1] and Fridolin Wild[2]

[1] Vienna University of Economics and Business,
Augasse 2-6, 1090 Vienna, Austria
felix.moedritscher@wu.ac.at
[2] Knowledge Media Institute, The Open University,
Walton Hall, Milton Keynes, MK7 6AA, United Kingdom
f.wild@open.ac.uk

Abstract. Personal learning environments (PLEs) require new ways to motivate and scaffold learners. In particular, practice sharing is of importance for learner-centric approaches in the scope of (technology-enhanced) lifelong learning, as it is an enabler for community building and sustaining. In this paper we elaborate prerequisites for 'good practice sharing' and explain how we realized these aspects in our PLE solution named Mash-Up Personal Learning Environments (MUPPLE.org). Finally, we argue for the utility of our MUPPLE approach by highlighting two different strategies of good practice sharing and their benefits for learning and community building.

Keywords: Personal Learning Environments, Practice Sharing, Environment Design, Learner Interactions.

1 Introduction

Learner-centric solution approaches to technology-enhanced learning, like personal learning environments (PLEs), tend to have the problem that learners must cope with competencies beyond the professional ones, e.g. with certain skills to handle technology or with social competencies to connect to and collaborate in learner networks. Such pre-requisites, however, hinder learners from using PLEs and related solutions and justify the necessity to realize mechanisms to support and motivate learners, amongst others through practice sharing. In this paper we clarify our view on PLEs, discuss necessary components of PLE-based learning, and introduce a good practice sharing approach for this specific context. Hereby, 'good' constitutes that the practices to be shared are created by learners and not experts (cf. best practices).

PLEs [1] comprise a technological infrastructure which empowers learners to design their learning environments to achieve own goals, i.e. to work on digital artifacts and collaborate with facilitators and peers in networked communities. Therefore, [2] outlines the importance of a pedagogical model which is centering the learner and not the organization. Additionally, [1] highlights relevant technological and pedagogical requirements for PLEs, like a certain degree of openness, controllability, system

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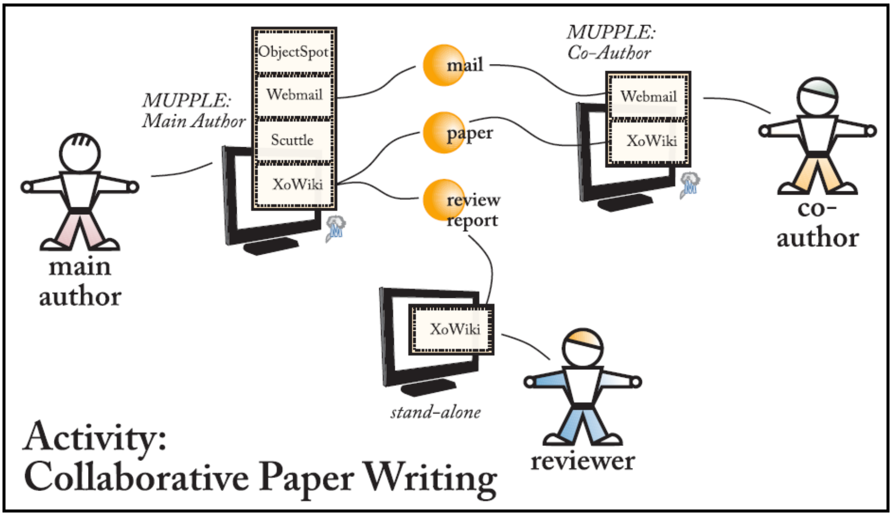

Fig. 1. Conceptual Diagram of an Action Flow within a Collaborative Activity

interoperability, personalizability, and so forth. In general, PLEs refer to any kind of environment, even the operating system and the software programs running on one's computer, but we use PLE as a synonym for web-based tool landscapes as we focus on networked collaboration.

To illustrate what PLEs look like, Fig. 1 describes a scenario, a so-called learning activity, which includes three actors who collaboratively write a paper. Each actor performs certain interactions with the learning environment, whereby they use different tools (search engine, email client, bookmarking tool, a Wiki) and work on different artifacts (mail, paper, review) to achieve their overall goal. Furthermore, each actor has a specific role within this learning activity. Thus, the reviewer uses only one tool (the Wiki) to accomplish her reviewing tasks, while the other learners need to cope with several tools for writing the paper, which is what we called a Mash-UP Personal Learning Environment (MUPPLE, cf. [3]).

Approaching technology-enhanced learning through personal learning environments requires the consideration of certain issues. The following section addresses typical prerequisites for practice sharing in PLE-based activities and points to related work in this field. Thereafter, we present our prototypical solution and explain how we have realized practice sharing for PLE-based activities. Finally, we give two examples for practice sharing, before the paper is concluded and next steps are indicated.

2 Ingredients for Practice Sharing in PLE-Based Activities

Practice sharing in personal learning environments is based on certain pre-requisites – technical and non-technical ones – which are explained in the following subsections.

2.1 Consideration of Transcompetences

While technology-enhanced learning driven by organizational needs primarily address professional competences, PLE-based approaches build upon certain additional skills beyond a certain domain, i.e. social, self, and methodological competences (transcompetences). Addressing social networking for lifelong learning, [4] outline the importance of self-organizing and knowledge sharing capabilities of learners, which can be supported by visualizing the social network, games for promoting discovery, socialization, and collaborative behavior, stimulus agents, or policies for managing the network. Furthermore, [5] argue for the necessity of self-directed competence management in ad-hoc transient learning communities. Finally, [3] states that learning environment design capabilities, e.g. hands-on skills to design and use one's learning environment, are required. All these transcompetences need to be considered and supported when dealing with learner-centric TEL approaches.

2.2 Activity-Oriented Model of Learning

Closely related to competences necessary for PLEs, practice sharing within PLE-based activities has to be grounded on a simple, domain-independent, action-oriented pedagogical model to structure the learning context and formalize learner interactions. In [3] we argue for a semantic model based on the Activity Theory which defines an activity as a set of user-defined statements (action-outcome-tool triplets), each one representing a learner interaction. With the action we refer to a term describing what the PLE user (subject) is doing (predicate). The outcome (object) stands for what is being achieved with the action. An outcome can be either abstract (e.g. a goal) or concrete (e.g. a shared artifact). A tool or even a tool combination is considered to be the instrument necessary to complete an action. Examples for such statements are 'publish self-description using VideoWiki' or 'bookmark search results using Scuttle'. Overall, this simple language allows describing how a learner is utilizing software tools while acting and trying to achieve the outcomes. Hereby, the activity itself serves as a container for a set of learner actions related to a specific purpose. Examples for typical activities are 'Collaborative paper writing' (cf. Fig. 1) or 'Getting to know each other'. However, it has to be stated that this model of a learning activity describes the view of one learner only and, therefore, allows multiple versions of an activity, e.g. one for each specific user role or even one for users having the same role and personalizing their PLE to their very own needs.

2.3 Materialization of Environment Design and Learner Interactions

In addition to modeling learning activities, learner-centric approaches are closely related to relatively new ideas such as end-user development and opportunistic design. According to [6], end-user development is one emerging paradigm observable in many application areas and evolving systems from being 'easy to use' to being 'easy to design'. Similarly, [7] report about opportunistic design and development (mash-up design) as a new software engineering methods, i.e. mashing up pieces of source code for new purposes. Considering these two streams, PLE solutions tend to shift the locus of control from expert designers to end-users. Formerly, we identified the need for materializing environment design and learner interactions and, consequently, introduced a scripting language [3]. Such 'learner interactions scripts' comprise the learner-defined action statements introduced in the last subsection as well as 'support' statements which are pre-defined and based on the possibilities of the PLE solution and its presentation layer. E.g. for our PLE approach we built upon web application mash-ups visualizing all learning tools next to each other within the browser and providing drag-and-drop functionality to arrange and use the windowed tools (more details are given in section 3). More independently of the presentation layer, our PLE prototype also tracks if a learner selects, minimizes or maximizes a tool, combines tools, completes or resumes an action, etc. Overall, the (open, learner-given) set of action statements describes for which actions and outcomes the tools are used within her PLE, while the support statements are necessary to materialize learner interactions, i.e. how learners arrange the tools on their screen (for MUPPLE: on their mash-up space) and how they interact with them.

2.4 Facilities for Initiating and Regulating Networked Collaboration

So far, we highlighted the components enabling PLE-based learning activities from the perspective of a single learner. The next step towards the scenario visualized in Fig. 1 concerns aspects of networked collaboration. Extending our view on PLEs, learners should be empowered to connect to networks of actors, artifacts, and activities. Historically, the concept of learning networks has evolved from applying communication over computer networks to bring together educators and learners and enable networked learning with the aim of creating and sustaining communities [8]. Similarly, research on computer-supported collaborative learning (CSCL) addresses networked collaboration, e.g. through scripting such activities [9]. The earlier-mentioned 'learner interaction scripts' which describes how a learner has designed and used her PLE can be synchronized with the scripts of the collaborators to receive a model of the action flow within an activity. Synchronization points are, in fact, the outcomes, e.g. shared artifacts, and the tools used. The soundness of this approach has to be shown similar to workflow mining approaches [10] and runtime behavior problems of executing concurrent workflows [11]. At this time, fault prevention is considered to be future work; in our current prototype the most prominent problem, concurrent editing of artifacts, is left to the tool utilized by the collaborators.

2.5 Technical Requirements for Tools Used

At last, there are (of course) also technical requirements which partially depend on the PLE front-end. Hereby, the presentation layer of our MUPPLE prototype (the web application mash-up solution) requires certain restrictions of HTML code of the learning tools. Amongst others, a web application to be applied within MUPPLE has to provide a REST interface, so that learners can use different urls for their specific actions. Furthermore, these tools are not allowed to provide redirect mechanisms or links which destroy the MUPPLE page including the application – a rather insignificant restraint. Independently of the technological framework, tools for learner-centric TEL approaches also needs to support a certain degree of interoperability – beginning from data interoperability over PLE design up to a widget communication API –, so that learners can combine two or more applications for real-life scenarios. For instance, an action 'bookmarking' might be realized through one tool that allows users selecting entries (like a search engine) and another tool for managing the entries (like a social bookmarking tool). Therefore, these tools require an interoperability mechanism, like the OpenSocial API, enabling data exchange between tools. For our MUPPLE approach we built upon distributed feed networks slightly extended by a mechanism for active management of subscriptions (cf. [12]).

3 Mash-Up Personal Learning Environments (MUPPLE.org)

Following the ideas of learner-centered TEL, we developed an infrastructure called Mash-Up Personal Learning Environments which stands for a learning environment designed by the learner and consisting of several tools to be used within one activity.

3.1 Conceptual Approach

In [3] we looked back at the history of instructional design and personalized, adaptive learning and formulated a critique on contemporary models and theories. In particular, we came to the conclusion that learning environment design is the missing link for personalized learning, and is even able to avoid the flaws of prior adaptation theories in technology-enhanced learning. This is strongly based on three assumptions:

- First of all, we prefer the idea of '*learning to learn*' while at the same time learning content, to just (re-)constructing domain-specific knowledge. Thus, we emphasize the *acquisition of transcompetences* (i.e. social, self, and methodological competence) in addition to content competence (see subsection 2.1). Furthermore, we build upon the model of learning activities introduced in subsection 2.2.
- Second and consequently, we consider the *learning environment* an important part of the *learning outcome* as opposed to an instructional condition. Therefore, personalization does not take place within a certain learning platform and driven by the system, but through learners *designing their learning environments* (see also subsection 2.3) and establishing a *network of people, artifacts, and tools* (manually or with the support of personalization services) and interacting with that environment (cf. subsection 2.4).
- Third and finally, we consider emergence of behavior as an unavoidable and natural phenomena of interacting with complex socio-technical systems. By emergent behavior we mean that the observable dynamics show unanticipated activity, surprising in so far as the participating systems have not been instructed to do so specifically (they may even not have intended it). *Designing for emergence* is in our view more powerful than rules-based personalization, as the models involved are simpler while achieving the same effect.

Technologically, we built upon a flexible architecture, i.e. a 3-layered framework for distributed systems as an enabler for end-user development of learning environments. The backend layer deals with data-interoperability, for instance in the form of RSS feeds or Simple Query Interfaces (SQI). The middle-ware layer includes typical service APIs between the different systems, e.g. in the form of mediation, retrieval, or feed management services (see also [12]), while the presentation layer on top comprises the user interfaces of the involved learning tools in the form of a mash-up.

3.2 The Learner Interaction Scripting Language

We have developed a domain-specific language named ‘Learner Interaction Scripting Language’ (LISL) to be able to materialize user-driven environment design. Fig. 2 gives an example of such a script in which the statements comprise exemplary learner interactions for designing and using the environment. The language per se is kept simple, i.e. allows the definition of action-outcome-tool triplets, starting and completing these actions, connecting tools with each other, and interacting with the windowed tools (earlier referred as support statements). Furthermore, networked learning can be identified by synchronizing the scripts of the learners involved in one activity, e.g. according to the shared artifacts.

Specialties of LISL are its lazy definition mechanism for action-outcome-tool triples and the placeholder mechanism for urls. Hereby, lazy definition refers to the idea that the entities of an action statement (action, outcome, or tool) does not need to be predefined, but will be defined on executing the statement. Thus, LISL can be also used to describe non-computerized activities, such as ‘*(I) sign a contract by using a pen*’. On the other hand, placeholders in urls allow de-personalization and personalization of LISL scripts. If a url is assigned to one action statement, parts of it can be replaced by a ‘variable’; on executing this action (i.e. launching the url within a window on the web application mash-up space) the value is either pre-defined or requested from the learner. Placeholders are of particular interest for practice sharing, as shown later on.´

Overall, LISL is considered to be the underlying model of environment design and learner interactions with MUPPLE. Thus, it is useful to materialize the interactions of a learner. However, in the sense of end-user development [6], learners do not need to script their environment manually but can use web-based widgets, which creates the script in the background. Similarly to AppleScript or VBScript, LISL can be utilized by ‘power users’ to be more efficient in designing environments, for instance if they prepare MUPPLE pages for others. Normally, learners are expected to use the web-based widgets and the tools started by them to achieve their activities successfully.

```
 1>   define action compose with url http://[...]?action=create
 2>   define action browse with url http://[...]/%%peers%%
 3>   define action bookmark
 4>   define object ‘self-description’
 5>   define object ‘peers’ with value ‘group_a’
 6>   define object ‘selected descriptions’
 7>   define tool VideoWiki with url http://videowiki.icamp.eu
 8>   define tool Scuttle with url http://scuttle.icamp.eu
 9>   connect tool VideoWiki with tool Scuttle
10>   compose object ‘self-description’ using tool VideoWiki
11>   browse object ‘peers’ using tool VideoWiki
12>   bookmark object ‘selected descriptions’ using tool VideoWiki
13>   drag tool VideoWiki to column 1
```

Fig. 2. Example LISL Script including three learner interactions (lines 10 to 12) and several supportive statements (define, connect, and drag)

3.3 The MUPPLE Prototype

On executing a LISL script, the web application mash-up for the chosen activity is built up and provided to the learner. Fig. 3 displays an exemplary MUPPLE page consisting of a header at the top, navigation and creation facilities on the left hand side, and the content area (the mash-up of tools) in the center.

The header simply presents the type (e.g. an activity) and the title of the current page. Navigational elements comprise a list of own activities. Clicking on one activity folds out the list of actions contained and loads the MUPPLE page into the content area, restoring the state in which the learner left it previously. Furthermore, creation facilities enable users to create new activities or add action statements (action-outcome-tool triplets with recommended values and urls) to the page opened. The content area consists of three tabs: The tab 'preview' displays the mash-up of the windowed learning tools involved into the current activity. Here, learners can arrange the windows to their needs and preferences, i.e. drag and drop them along a grid-based layout, minimize, maximize, or close them. The tab 'code' allows in-code editing of the LISL script of the current MUPPLE page. The tab 'log' shows the results of the web-based LISL interpreter (including error messages and warnings for single statements) and enables power users to test their own LISL statements.

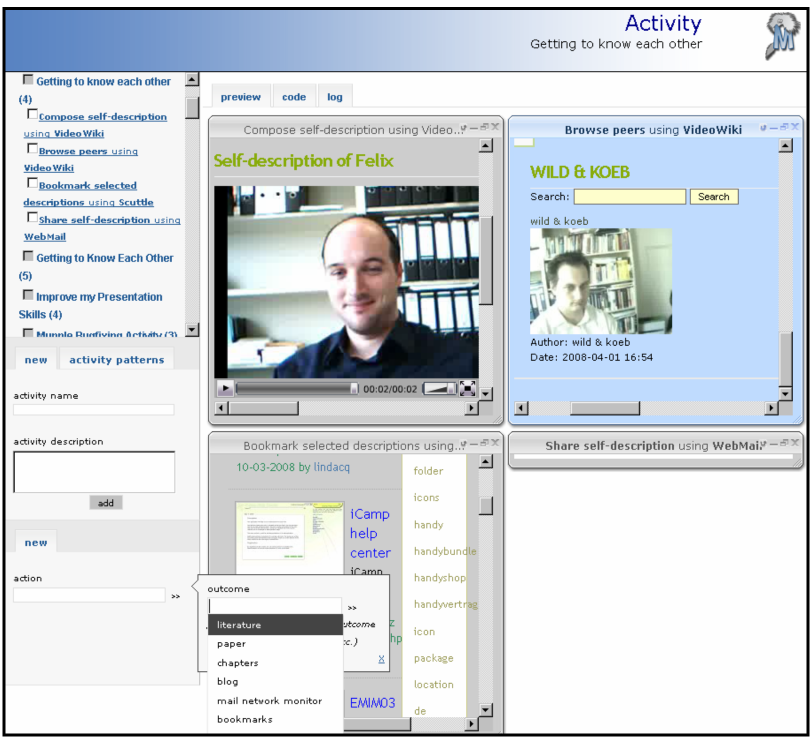

Fig. 3. MUPPLE Page for an Activity 'Getting To Know Each Other'

According to [3], this three-tabbed content area for MUPPLE pages is justified by various principles for end-user development. This infrastructure is considered to be an enabling technology for practice sharing, as shown in the upcoming section. Preliminary evaluation studies showed that the usability of MUPPLE and the learning tools is crucial, so we improved the user interface of the prototype iteratively and added several fancy functions like auto-completing recommendations (similarly to the Google search field) or the Ajaxian dialog boxes (both shown in Fig. 3).

4 Two Examples of Sharing Good Practice

Basically, a PLE can include 'automated' and 'user-driven' practice sharing strategies (or hybrids). Our MUPPLE prototype realizes both through different features.

4.1 Practice Sharing through Activity Templates

User-driven practice sharing is achievable by using LISL scripts. This scripting language does not only materialize how learners design and use their learning environment, but can also be used for practice sharing. In this context, we call LISL scripts 'activity patterns' which users can instantiate as a new MUPPLE page, as they make it easier to reuse successful environment designs and user interaction sequences for an activity. Patterns can be created by a learner whenever she thinks that one activity is qualified as a pattern and thus is 'good' enough to be shared with peers. For these patterns, the earlier-mentioned placeholder mechanism is of importance, e.g. for depersonalizing one's activity (e.g. remove parts of a url for privacy reasons) or to enforce learners to initiate and customize the derived activity appropriately.

As an example, the activity 'Collaborative Paper Writing' (visualized in Fig. 1) might be described by three role-dependent patterns including different sets of action statements. For instance, the main author has to take care of several administrative tasks, like assigning the chapters to co-authors, requesting the (internal) reviews, and submitting the paper. Furthermore, she has the same duties like the co-authors, i.e., finding and collecting relevant literature, summarizing related work, and elaborating the paper. On the other hand, reviewers only need to check the collected literature and comment the paper. In our example, they use the commenting features of a Wiki to give feedback on the paper. The urls of these patterns could include placeholders (e.g. 'http://%%my_host%%/%%my_path%%' instead of the full url). Consequently, this user-driven practice sharing allows initializing the MUPPLE platform with meaningful patterns for specific target groups, which might be a strong reason for learners to join a community or, at least, to register and log in.

4.2 Automated Generation of Recommendations

Another possibility to support learners in designing their environment deals with providing recommendations for their activities and actions. On creating a new activity from a pattern, MUPPLE displays a learner the list of all patterns available, ranked according to the number of activities derived from each pattern (left-hand side of Fig. 4). Moreover, inexperienced learners have an overview of the five most popular patterns at the entry page of MUPPLE (right-hand side of Fig. 4).

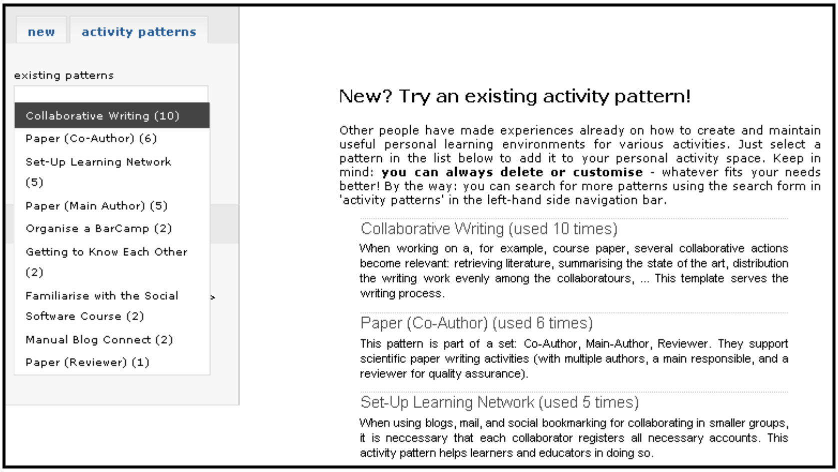

Fig. 4. Recommendation of Activity Patterns According to Usage Frequency

Therefore, all activities are analyzed automatically in order to extract recommendations for patterns, actions, outcomes, and tools (including their urls). So far, actions, outcomes and tools are also ranked according to the number of their occurrences, whereby this ranking is improvable by considering the semantic structure, i.e. the closeness to an activity or the action-outcome-tool bindings. Automated approaches like our recommendation services are of particular interest to support learners in designing and using their PLEs, e.g. to empower design capabilities. However, for both kind of practice sharing and the MUPPLE pages itself it is important to leave the control over the system to the learner, so that she can adapt the tools and mash-up space according to her need and preferences.

5 Conclusions and Outlook

Summarizing this paper, we have shown that there are five important prerequisites for practice sharing in learner-centered environments: (1) the consideration and support of transcompetences, (2) an activity-oriented model of learning, (3,4) a formalism to describe environment design and networked collaboration, and (5) specific technical requirements. Considering these issues for a PLE solution, it is possible to provide valuable facilities for good practice sharing, so that learners are supported in designing their environments and tools to succeed in their activities. Most importantly, practice sharing is considered to be necessary to avoid the cold-start problem of PLEs, i.e. to provide starting points and scaffolds from which users' can adapt further. Evaluation studies in the scope of higher education evidenced that inexperienced PLE users (learners and educators) normally do not use Web 2.0 tools. Thus, it is necessary to provide a mechanism for automated identification of users at the different tools in order to not annoy them. Furthermore, those learners not being familiar with web-based applications rather reused activity patterns while technology-skilled users started to play around with MUPPLE and create own activities from the scratch.

Consequently, we assume that PLE-based TEL approaches highly focus on transferring good practices from experienced, high-skilled learners to the rest. Finally, we are aware of specific shortcomings of MUPPLE, e.g. a lack of interoperability or widgetization of existing tools.

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What If Annotations Were Reusable: A Preliminary Discussion

Nikos Manouselis[1] and Riina Vuorikari[2]

[1] Greek Research & Technology Network
56 Messogion Str.
Athens, Greece
nikosm@ieee.org
[2] European Schoolnet, Rue de Treves, 61,
1040 Brussels, Belgium
Riina.Vuorikari@eun.org

Abstract. This paper discusses the rationale for the representation of user feedback in a structured and reusable format so that it can be reused by different recommender systems. We emphasize how information about the context can be included in such a representation. This work-in-progress takes place in the context of two large European initiatives that set up collections of digital educational resources in distributed repositories to serve the needs of different user communities, and to collect user feedback such as ratings, bookmarks and tags related to the resources. The overall aim is to facilitate the exchange and reuse of their data sets in order to support recommendation of appropriate resources to the end users.

Keywords: Learning resource metadata, annotations, interoperability, reusability, data set.

1 Introduction

A representation of implicit or explicit feedback from the users regarding the candidate items is required by a recommender system to produce a recommendation. This feedback can be in several forms. For example, in the case of collaborative filtering systems it can be ratings or votes (i.e. if an item has been purchased, viewed or bookmarked). In the case of content-based recommenders, it can be product reviews or simple tags (keywords) that users provide for items. Additional information is also required such a unique way to identify who provides this feedback (user ID) and upon which item (item ID). The user-rating matrix [1] used in collaborative filtering systems is a well-known example.

User feedback representations are stored as data sets that can be used in a number of ways. A very popular use is in the context of evaluation experiments. Published data sets, such as the MovieLeans and EachMovie ones, are very often used in experiment testing the performance of new algorithms [2]. Less often, such experiments are based on usage data sets from particular applications (e.g. to support the needs of an existing e-commerce site). This means that in many evaluation experiments, testing takes place using data sets that are different than the ones of the potential application context. We

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believe that a structured way to represent the different types of user feedback in a reusable and interoperable format, while also maintaining information about the context in which this user feedback has been collected, could prove of particular value.

This would be particularly useful in scenarios where different online environment want to exchange the feedback that users have provided upon the same items, so that they can enhance the available data for their recommender systems. We deal with such situation in two European initiatives that both collect user feedback on digital educational resources: the Metadata Ecology for Learning and Teaching (MELT, http://info.melt-project.eu) and the Organic.Edunet (http://www.organic-edunet.eu) eContentplus projects.

In this paper we describe our first steps towards deciding upon a common representation format so that the two projects can collect, store, and exchange data sets containing ratings, bookmarks and tags by their users. It is continuation for the work presented at RecSys07 Doctoral Symposium [3].

2 Problem Description

The main questions discussed in this paper are: (a) can we find a way to represent and store data sets with user feedback in a structured, interoperable and reusable format?; and (b) is it safe to assume that some given data set with user feedback, which is stored in such a structured, interoperable and reusable way, can be used in other context, such as a new recommender system of a different application context?

Figure 1 illustrates one of the main problems to be addressed in a rather simplistic way. In this figure, the same movie can be found as an item (e.g. for a review, purchase, viewing, downloading) in three different application contexts: one movie

Fig. 1. Ratings on the same items from different contexts

recommender system, one e-commerce site, and one educational portal. Users in all three sites are rating the same movies, depending on the potential use they envisaged. For example, the user of the movie recommender rates the movie according to how much he appreciated/enjoyed it, independently on whether this movie can be easily found or its price. On the other hand, using an e-commerce site a user may rate the movie considering the availability and cost of the particular product package (e.g. DVD). Moreover, on the educational portal, the movie will be rated according to its potential value as a teaching or learning aid.

This simple example illustrates why we believe user-provided feedback can be of particular value when made available for reuse from other systems, but after considering that the two systems may be collecting feedback in a totally different context. For instance, this example describes why it would be probably misleading to use the rating data captured by the movie recommender to test the performance of a recommender system in an educational context. On the other hand, one cannot overlook the value that an existing user feedback (e.g. past ratings) has, as they are upon items that are candidate for recommendation in both systems. To this end, we argue that (ideally) user feedback:

(a) should be represented in general in a structured, reusable and interoperable format that can be shared among different systems;

(b) should incorporate some information about the context in which it has been collected.

3 Capturing User Feedback

Capturing and taking advantage of users' actions on the Web has come a long way since business models were first implemented around the idea of click-stream in the '90. Instead of having the commercial sites taking advantage of the attention that users pay to different products, in the recent years the tide has turned arguing that interactions with the content (e.g. buying, listening, reading feeds) and users reactions to that content (e.g. ratings, reviews, tags) should be something that the user can control. AttentionTrust.org (http://www.attentiontrust.org/), for example, calls this "attention data" and argues that it is a valuable resource that reflects user's interests, activities and values, thus serves as a proxy for their attention.

AttentionXML [4] is an open specification to capture individual's clicks to track user's behavior and information consumption on the Web. Attention Profiling Markup Language (APML) (http://www.apml.org/), on the other hand, offers a way for a user to create a personal Attention Profile, which is portable, sharable and captures users' attention on self-defined services.

The first elaboration of AttentionXML for the technology enhanced learning domain has been the Contextualized Attention Metadata (CAM) schema [5]. The CAM schema allows capturing observations about users activities in any kind of tool (not just a browser or newsreader as AttentionXML), with a particular focus on educational software. It has been initially designed to store information about what has attracted users' attention when working with several tools, and to store the interactions of the user with these tools. It also allows storing some basic information about comments, tags or ratings that a user provides when viewing a particular item.

```
<title>Attention stream of Jehad Najjar</title>
<feed>
  <title>Ariadne Indexation and Search Tool</title>
- <item>
    <title>Java lesson on inheritance</title>
    <type>html</type>
  - <events>
    - <event>
      - <action>
          <actionType>read</actionType>
        </action>
        <dateTime>2007-11-17T09:30:47.0Z</dateTime>
        <duration>120</duration>
      </event>
    - <event>
      - <action>
          <actionType>evaluate</actionType>
          <describingSchema>http://www.LRE.com/EvaluationValues</describingSchema>
        - <relatedData>
          - <entry>
              <name>Overall</name>
              <content>4</content>
            </entry>
          </relatedData>
        </action>
        <dateTime>2007-11-17T09:35:40.0Z</dateTime>
      </event>
    - <event>
      - <action>
          <actionType>tag</actionType>
        - <relatedData>
          - <entry>
              <content>Climate change</content>
            </entry>
          </relatedData>
        </action>
        <dateTime>2007-11-17T09:37:50.0Z</dateTime>
      </event>
    </events>
  </item>
</feed>
```

Fig. 2. XML example of CAM attention feed

Figure 2 presents an excerpt of XML code storing information according to CAM. It illustrates how ratings and tags are stored within the schema. More specifically, when a user interaction takes place, an event is recorded. This event belongs to a particular actionType, such as ‘evaluate’ (when a rating is given) or ‘tag’. The information that the user provides is stored as an entry with some name and content values. It may also be compliant to some describing schema (e.g. if a particular rating scheme is followed). The figure presents only an example of CAM record, which could also store additional information about the performed action and its input (e.g. the language of a tag).

Attention metadata such as the one stored by CAM can be used for recommendation purposes, since it includes all types of user feedback (e.g. ratings, bookmarks, purchases, tags, reviews). On the other hand, in order to collect usage data that has been stored with some specification such as CAM, the following requires attention:

(a) To define the exact type and structure of the information stored (e.g. if it is a rating value, what is the scale or the criterion used?);

(b) To define a way this information can be exported from a given context to be used in another context (e.g. how can ratings or tags be exported and used by some recommender system?).

In the next paragraphs we will try to elaborate on these two issues.

4 Annotation Schemes

An important issue related to the representation and export of user feedback data sets from a given application environment is the declaration of the type(s) of feedback that is being collected and its format. For example, such an exported data set has to declare if the collected information is in the forms of ratings, reviews, or tags. In addition, it has to declare the exact structure and value spaces of the collected feedback. For instance, ratings may be collected upon one or more attributes (criteria), and using different rating scales. This can be particularly evident when examining evaluation or quality models for different application areas. In technology enhanced learning, we have found that rating of learning resources takes place using a variety of review schemes or instruments [6]. We call the definition of the structure and value space of some user feedback type as an annotation scheme: this can refer to a particular model, set of criteria, or instrument that is used for collecting user feedback in a particular application environment.

In order to facilitate interoperability between different systems, and potential reusability of exported user feedback in other application environments, we argue that it is important to define the particular annotation scheme used. This is illustrated in the example presented in Figure 3. The movie recommender uses an annotation scheme that collects single-attribute ratings on movies and reflects users' overall satisfaction using a scale between 1 and 5. The e-commerce site, on the other hand, collects ratings on products. In this case, the ratings are collected using a scale from 1 to 7 upon different attributes (e.g. the quality of the product, its cost, and its availability). Additionally, textual product reviews by users are collected. Lastly, there is the educational portal that collects user feedback by asking users to rate their overall satisfaction with the item on a scale 1 to 7. Users can also provide their own tags to the items. Imagine that a recommender system would like to reuse the ratings on the same items (e.g. movies) that are collected by all three applications. In order to appropriately combine and transform existing ratings in a comparable format, the new system has to know (i) which annotation scheme has been used and (ii) its particular properties.

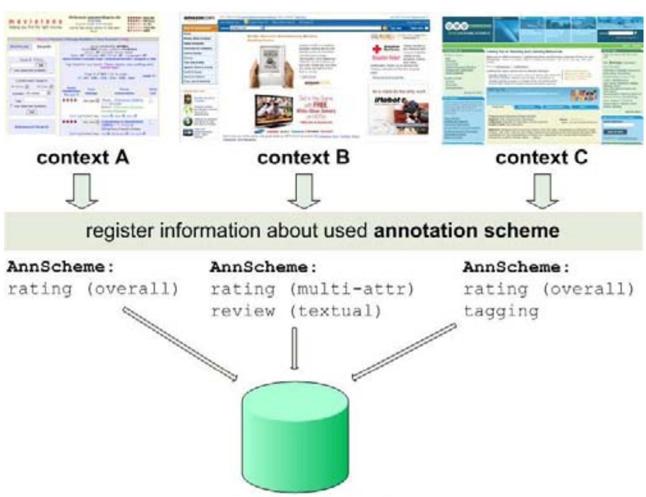

Fig. 3. Registering the annotation scheme used in some context

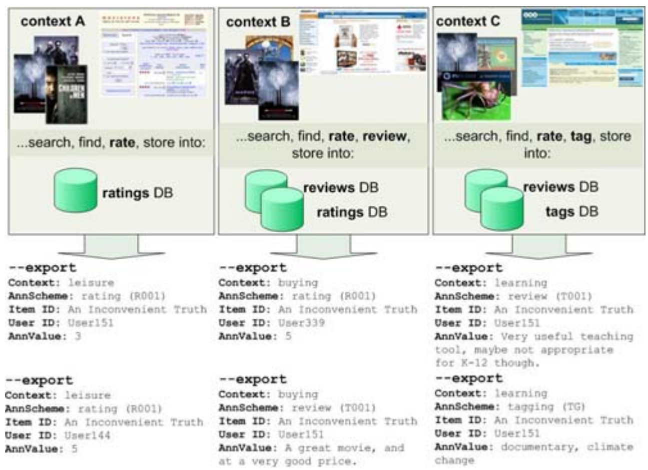

Fig. 4. Exporting annotations from different contexts

For the case under study, the solution of developing a registry of annotation schemes for learning resources has been chosen. In this way, it can be made possible for a learning resource collaborative filtering system [7] to collect ratings from different environments, and to refer to the annotation registry in order to appropriately combine or transform them. Similarly, existing textual reviews or tags can be collected and reused. For the Organic.Edunet project, a common annotation scheme registry will be developed, so that it is used as a reference point by all online access environments that collect user feedback. It is our intention to offer this registry openly for use by other initiatives in the domain of digital educational resources.

5 Collecting Data Sets

When the time comes for an application that collects user feedback to share this information with other applications, an appropriate transformation has to be followed. Figure 4 outlines how a data set could be transformed and exported in the conceptual example that we have used so far. The three different application environments that we consider are not simply dumping the user data in their databases with ratings, reviews or tags. They follow a more structured representation, and also export information about:

(a) the context in which this user feedback is collected, so that other applications can decide if and how they should reuse this particular feedback;

(b) the annotation scheme used, so that other applications can find out which annotation scheme has been used and appropriately transform the exported data into a format of its needs.

In our case study of annotating and recommending learning resources, this information is stored according to the adopted CAM schema (Section 3) into a central CAM repository. In this way, it is made available to all the different applications that can be developed to take advantage of this data.

For instance, Organic.Edunet will develop a collaborative filtering service for learning resources [7]. This service can search for user ratings that have been collected upon various resources from the CAM repositories of both MELT and Organic.Edunet, refer to the annotation scheme registry in order to decide how the collected ratings can be transformed into a comparable format, and use them as input for producing new recommendations. In a similar way, MELT can collect tags from MELT, Organic.Edunet and other educational portals (such as OERCommons, http://www.oercommons.org/), in order to use them in a cross-repository way (e.g. creating cross-repository tag clouds). Additionally, this type of data sets can be used to run evaluation experiments of new algorithms to be used in an educational context.

The requirement for the application environments that collect user feedback will only be to export their data sets in a CAM-compliant way, so that it is stored in a reusable manner in the centralized CAM repository. This can be either manually performed at some points in the lifetime of the systems or through a regular harvesting procedure (e.g. using OAI-PMH, http://www.openarchives.org/).

6 Pilot Implementations

The ideas described in the previous section have been implemented in the initial version of a Social Navigation Module that aims to support recommendations of learning resources in federations of learning repositories. At the moment, the Module is being integrated with the collaborative filtering service of Organic.Edunet. It is also explored, how it can support recommendation in the context of the LRE portal (http://lreforschools.eun.org).

Figure 5 illustrates how the Social Navigation Module is collecting user annotations from the Organic.Edunet Web Portal, and also provides recommendations based on these annotations. It also shows that in a similar way, other Web portals can be supported by invoking the relevant services. In addition, Figure 6 shows an example

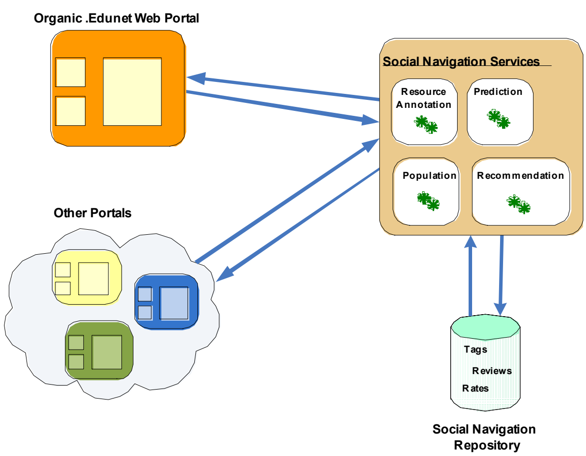

Fig. 5. Architecture of Social Navigation Module and how it supports Organic.Edunet

of how the different features of the Social Navigation Module can be provided through the interface of a Web portal. More specifically, it illustrates primitive interfaces for collecting tags, reviews and ratings from some user, and calculating a collaborative filtering prediction out of these annotations. Although this is a draft interface design that does not show how the features can be integrated into a fully operational system (e.g. Organic.Edunet Web Portal), it gives an indication of the way the Social Navigation Module can be invoked to support recommendation.

7 Other Potential Uses

Apart from the implementation in the context of the two European projects that has been outlined above, the representation of user feedback in a structured, reusable and interoperable format can add value for other envisaged applications as well. Let us consider the case of some user that is regularly using a number of different educational portals (e.g. OERCommons, MERLOT, http://www.merlot.org) in order to find, access, view or download learning resources that she finds listed there. Apart from using these resources for her own learning or teaching needs, the user can also provide feedback such as ratings, tags and pedagogical descriptions of usage.

Instead of storing her feedback in the server of the OERCommons, we could envisage the storage of this data in her own personal portfolio of resource annotations. In this way, feedback can be collected when she visits and annotates resources listed in other educational portals (such as MERLOT) or in other popular sites (like Amazon). When logging into the OERCommons portal again, her personal tag-cloud can be enriched with tags that she has provided in other environments that operate in an educational context. Or, when she logs into Amazon in order to get personal recommendations about appropriate textbooks for her teaching, the textual reviews that she has provided in the OERCommons portal and the ratings that she has provided on similar items in the MERLOT portal can also be considered.

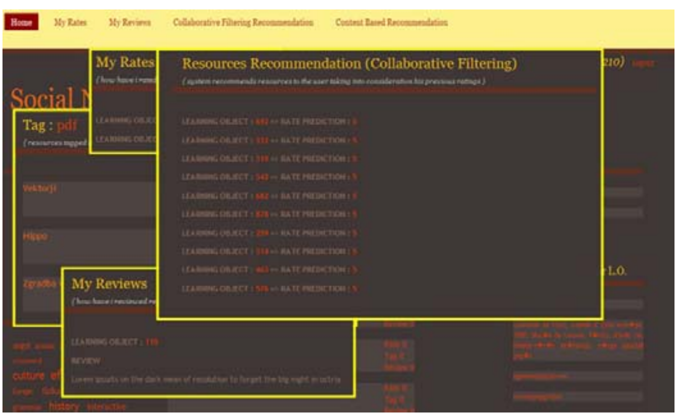

Fig. 6. Example interface of Social Navigation features

8 Conclusions

Overall, we believe that the potential of collecting user feedback in a structured, reusable and interoperable (i.e. commonly agreed) format is high. In the context of MELT and Organic.Edunet, a Social Navigation Module is being developed based on the CAM-oriented approach presented in the paper. This Module aims to support recommendation of learning resources in federations of learning repositories." we currently implement the CAM solution examined above, and we expect to have some initial output for demonstration later in 2009.

However, several issues have to be addressed in order to apply such solutions in a larger extend. For instance, an important requirement will be how to uniquely identify the users when changing from one system to another (especially if they are using different user IDs) or the items when they are catalogued in different systems (especially when referring to items that do not have a specific URI). In addition, the adopted CAM solution is a rather user-oriented solution (since it captures attention streams of particular users) and collects very large information streams. The way that this will be implemented in scenarios such as the one examined in Section 7 has to be explored, in order to achieve fast data transfer and on-the-fly calculation of recommendations.

The approach presented in this paper seems promising, but there is a number of issues that still have to be elaborated and explored. For example, more work has to be carried out on how the context in which user feedback is collected can be represented (especially as far as the "learning" context is concerned), and how this information is actually used. Furthermore, the pilot implementation of the approach in the Social Navigation Module can provide a test bench for an evaluation experiment that will verify the reusability of the annotations. Finally, the criteria upon which learning resources are assessed also affect the meaning of the recommendation. That is, it is different if learners assess their overall satisfaction from using a particular resource, in comparison to teachers assessing how this resource can be used as a teaching aid. This is another important reason for further exploring the dimensions used to represent the context and the preferences of users, when feedback is collected.

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Toward an Integrated Competence-Based System Supporting Lifelong Learning and Employability: Concepts, Model, and Challenges

Yongwu Miao, Marcel van der Klink, Jo Boon, Peter Sloep, and Rob Koper

Centre for Learning Sciences and Technologies, Open University of the Netherlands
{Yongwu.Miao,Marcel.vanderKlink,Jo.Boon,Peter.Sloep,
Rob.Koper}@ou.nl

Abstract. Efficient and effective lifelong learning requires that people can make informed decisions about their continuous personal development in the different stages of their life. In this paper we state that lifelong learners need to be characterized as decision-makers. In order to improve the quality of their decisions, we propose the development of an integrated lifelong learning and employment support system, which traces learners' competence development and provides a decision support environment. An abstract conceptual model has been developed and the main design ideas have been documented using Z notation. Moreover, we analyzed the main technical challenges for the realization of the target system: competence information fusion, decision analysis models, spatial indexing structures and browsing structures and visualization of competence-related information objects.

1 Introduction

At the moment we are experiencing the effects of the transition from the industrial to the knowledge economy which is characterized by a dynamic market, severe changing occupations, and insecurity of jobs [13]. Some qualifications are becoming obsolete but emerging new competences require continuous, lifelong learning and development of large categories of employees. Policy makers in OECD countries are concerned about the possible negative consequences of this transition to the knowledge economy because it may lead to a decrease in employability and job security over the career [3]. Remaining attractive and employable in the 21st century implies that employees become more accountable for investments in their own human capital and hence in their own job security, learning and career development [8]; this presupposes a high level of self-directedness in career and learning processes. Research, however, indicates that for large groups of employees self-directedness is not a natural habit. They lack the meta-cognitive skills to steer their own career and learning process and can not pro-actively recognize and utilize opportunities [12, 18]. For large groups of employees their learning is mainly restricted to responding to changes in work tasks, they do not set goals, monitor or evaluate their learning. The notion of the self-directed employee is perhaps more an ideological concept than a wide-spread

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reality. Apart from the fact that employees are not always able or willing to steer their own lifelong learning, there is also the real danger that employees experience severe difficulties in choosing the right career steps, and the best learning and training activities out of the entire set of possibilities, which was clearly demonstrated in [1]. If we really want them to take charge of their own career and lifelong learning then we need to offer an infrastructure that supports them in the process of making informed decision about these issues.

A theoretical notion of Learning Network has been proposed [6, 7, 14] that addresses facilitation of lifelong competence development. A learning network is an ensemble of persons, institutions, and learning activities that are interconnected through and supported by information and communication technologies in such a way that the network self-organizes. A lifelong learner, a member of a learning network, can provide learning activities (e.g., courses, training programs, assessment, and learning materials) and can engage in a series of learning activities offered by others to reach a goal, such as acquiring a certain competence. In order to offer learning activities in learning networks, many different recommendation technologies such as structured and collaborative filter have been proposed along the years [4]. According to learner's goals/needs (represented in terms of competences with proficiency levels) and preferences (e.g., types, learning styles, and learning strategies), the personal recommender attempts to find all suitable learning activities and to rank them based on some measure of "goodness", so that the "best" matches receive the highest ranks. In TENCompetence project [17] various personal recommenders have been implemented as Learning Network services to offer learners with suitable learning activities. It releases learners' burden to search and choose learning opportunities.

Based on our experiences with this topic, we set out to develop an integrated system that not only supports lifelong learning, but also supports competence-based employment and related business processes. The benefits of such an integrated system could be to help lifelong learners to determine learning goals/needs and choose learning activities in the interest of lifelong employability, to seek suitable intellectual products and business opportunities, and to seek partners for making up a virtual company, and to support job-hunting and recruitment procedures based on automated competence tracking and management. For providing high quality recommendations in this system, at minimum two pre-conditions must be met: 1) information about competence-related objects such as persons, institutions, learning activities, assessment, tasks, jobs, and job applications has to be accurately and completely captured, 2) the criteria and analysis logic used to make decisions coincide with those of the learners. However, it is difficult to capture the reliable competence information [9]. Users may assess and represent competences of related objects higher or lower than the actual competences. In particular when applying for a job, a person may intentionally describe his/her personal competences higher. Sometimes, learners have no clearly outlined learning goals, needs, and preferences. In addition, these will likely change because of unforeseen and situated factors. They even change their criteria and analysis logic on the fly. Analogue to a tourist, s/he sometimes may have no particular destination when visiting a city. Goals, needs, and preferences may change as time and context changes. For example, he may be interested in getting information about hotels as he arrives and the information about restaurants at lunch time. He suddenly decides to visit a museum because he just now found out that this afternoon the museum charges no entrance fee and there is a bus line to the museum from the current position. When he makes decisions, the factors, criteria, and logic may change as well. Sometime, time is the most important factor and sometimes the cost is the more important factor. These changes may be situated and are triggered by unpredictable events. The final decision may be a compromise of several factors using multi-criteria. In these situations, recommendations based on pre-defined goals, preferences, criteria, and analysis logic may be not effective to create a set of "good" matches.

In this paper, we present the design of an abstract conceptual model of the target system. The design of this model is partially based on TENCompetence Domain Model [16] and partially based on Ostyn's work [10]. In particular, we design the model to address the problems described above. We design a data model necessary for: 1) dealing with inaccurate, incomplete, and inconsistent competence information, 2) involving lifelong learners in decision-making processes, and 3) presenting relevant competence information in a structured and visualized manner. The remainder of this paper is organized as follows. First we present the main concepts of the system as data types. Then we specify the conceptual model as state spaces using the defined data types. The section thereafter discusses the challenges for a realization of such a system. Finally, we present our conclusions.

2 Concepts

In this paper, we present the main design ideas (note: not a whole system design) using the Z language [15]. There are a number of reasons to choose Z. Firstly, Z has the advantage that it is able to specify a system accurately and unambiguously. Secondly, the functional specification can be used to express design ideas at an abstract level without specifying concrete implementation algorithms. Thirdly, Z can be used to describe a specification of a large system by breaking it down into a number of subsystems, which can be specified in separate documents piece by piece accompanied by informal explanation [15].

This section presents important concepts as data types. First of all, we define basic types. The following notations represent the types of natural number, integer, real number, Boolean, string, and text respectively as: [$\mathbb{N}$ $\mathbb{Z}$ $\mathbb{R}$ BOOLEAN STRING TEXT]. In order to ease discussion, we don't consider the detail and internal structure of some data types such as time, duration, status, meta-data, money, location, url, source, rating, percentage, and globally unique identifier in our model. These data types are introduced as basic types as well: [TIME, DURATION, STATUS, M_DATA, MONEY, LOCATION, URL, SOURCE, RATING, PERCENTAGE, GUID]

We acknowledge that the concept of 'competence' or 'competency' is the subject of ongoing discussion. According to IEEE Reusable Competency Definition (RCD) [11], a competency is defined as any form of knowledge, skill, attitude, ability or educational objective that can be described in a context of learning, education or training. RCD does not address the aggregation of smaller competencies into larger competencies. In this paper, we use the broadly recognized definition of Cheetham and Chivers [2] who defined competence as 'effective overall performance within an occupation, which may range from the basic level of proficiency through to the highest level of excellence'. According to this definition, a competence can be simply regarded as a competency in a particular context. In our model a *competence* is defined as a data type with attributes id, title, description, definition, and meta-data as does the RCD. Note that most data types defined in the model have attributes id, title, description, and meta-data. In order to save space, these attributes will not be specified for the other data types although the reader should assume their presence.

Competence

id: GUID; title: STRING; description: TEXT; definition: STRING; meta-data: $\mathbb{P}$ M_DATA

A *proficiency level* is used to evaluate a competence. According to the European Qualification Framework, we define ProficiencyLevel = $\{ r: \mathbb{R} \mid 0 \leq r \leq 8\}$.

In the *competence model*, a competence can be decomposed into several lower level competences which represent the facets of the competence, component competences, or both. As specified below, all competences in the model can form a directed acyclic graph (DAG). As an abstract model, the concrete decompositions of competences (the hierarchic structure) will not be discussed in detail in this paper.

CompetenceModel

competences: $\mathbb{P}$ Competence; isComponentOf: Competence $\leftrightarrow$ Competence

mapTo: $\mathbb{P}$ (Competence $\times$ ProficiencyLevel) $\twoheadrightarrow$ Competence $\times$ ProficiencyLevel

dom isComponentOf $\subseteq \mathbb{P}$ competences $\wedge$ **ran** isComponentOf $\subseteq$ competences

disjoint < isComponentOf^{+}, **id** Competence >

$\forall$ c, f: Competence; children: $\mathbb{P}$ (Competence $\times$ ProficiencyLevel);
father: Competence $\times$ ProficiencyLevel | c $\neq \emptyset \wedge$ f $\neq \emptyset \wedge$
c $\in$ **first** children $\wedge$ f $\in$ **first** {father} $\wedge$ (children $\mapsto$ father) $\in$ mapTo •
c $\in$ competences $\wedge$ f $\in$ competences $\wedge$ c $\neq$ f $\wedge$ (c $\mapsto$ f) $\in$ isComponentOf

A *competence profile* (CP) is a set of competences with associated proficiency levels that link directly to the work to be performed. Usually there are several competence profile items in a competence profile. Each competence profile is specific to a person, an institution, a software agent, a learning objective, an assessment, a task, a job, or a job application. We call all these entities competence-related objects. Note that each item in a competence profile is more or less credible.

CompetenceProfile

CompetenceModel;
competenceProfileItems: Competence $\times$ ProficiencyLevel;
confidenceRating: competenceProfileItems $\twoheadrightarrow$ PERCENTAGE;
creationTime: TIME;

A *person* represents a human user of the system in a computational form. The personalCP represents a claimed competence profile, which may be different from the potential/actual competence states of the person. The learning goals and learning needs are represented using competence profiles. The preferences such as preferred learning strategies, learning styles, and work styles are modelled using a basic type [PREFERENCE]. The reliability is used to represent the degree of trustworthiness of the person according to his/her behaviours in the system. This issue will be discussed later in the paper. A person should have more attributes to characterize him or her as a user in the system. These are omitted in this abstract model,

Person

name: String;	personalCP: CompetenceProfile
learningGoals: CompetenceProfile;	learningNeeds: CompetenceProfile
preferences: $\mathbb{P}$ PREFERENCE;	reliability: PERCENTAGE
availableTimeForLearning: DURATION;	availableMoneyForLearning: MONEY

An *institution* represents a company, a learning institute, a certification organization, etc. in a simple computational form. A *software agent* represents a software tool such as a pedagogy agent or a Latent Semantic Analysis (LSA) tool. We do not explicitly present the definitions. Note that data types Institution and SoftwareAgent have attributes institutionType/agentType and institutionCP/agentCP, repectively. The *actor* is defined as a generic term (data type) for a person, an institution, or a software agent as Actor ::= person <<Person>> | institution <<Institution>> | softwareAgent <<SoftwareAgent>>.

A *unit of learning* represents a course, a train program, a learning material, and etc that can be used for learning. A unit of learning is characterized in terms of a required competence profile and an objective competence profile. In this model, we do not consider the internal structure of a unit of learning.

UnitOfLearning

prerequisites: CompetenceProfile;	objectives: CompetenceProfile
creationTime: TIME;	estimatedTime: DURATION;
averageTime: DURATION;	averageRating: RATING
cost: MONEY;	type: UnitOfLearningType;
associatedResources: $\mathbb{P}$ RESOURCE;	features: $\mathbb{P}$ PREFERENCE;
location: LOCATION;	address: URL

A *unit of task* represents an abstract or an authentic work item. It can be used to represent a business opportunity and a training/assessment case for acquiring and demonstrating competences. A *unit of assessment* represents an online assessment, an interview, a simulator-based test, a 360 degree feedback, self-assessment, a formal examination, and etc. Because UnitOfTask and UnitOfAssessment are defined similar to UnitOfLearning, we do not explicitly present them in the paper. The primary difference is that UnitOfTask and UnitOfAssessment are characterized using one competence profile associatedCP, whereas UnitOfLearning are associated with two competence profiles. In addition, UnitOfTask and UnitOfAssessment have their own types. Note that taskType can be defined as an ontology, which can be referred to by jobs (see the definition below).

A *job* represents an open job offer. The status of a job may be valid, cancelled, expired, or recruited. The required competence profile is represented as requiredCP. What types of tasks one is expected to do can be listed in associatedTasks.

JobPost

status: STATUS;	owner: Institution
requiredCP: CompetenceProfile;	associatedTasks: $\mathbb{P}$ taskType
salary: MONEY;	location: LOCATION;
creationTime: TIME;	validDuration: DURATION

The data type of JobApplication is defined in a similar form to the JobPost, except that the claimedCP replaces the requiredCP and associatedEvidenceRecords replaces the associatedTasks. Note that in the JobPost and JobApplication, certain information that may be important in real recruitment, is omitted here for our purpose.

An *evidence record* is an information object concerning an actor and associated with a competence profile. Usually, it is based on certain forms of performance and assessment. The sources of an evidence record may be articles, designs, models, responses to questionnaires, interview protocols, certificates, and demonstration recorded in various forms of media. Obviously, different evidence records merit different levels of confidence. An evidence record may be provided by a person her or himself or by someone else at a point of time.

```
┌─EvidenceRecord ──────────────────────────────────────────
│ status: STATUS;                      owner: Person
│ associatedCP: CompetenceProfile;     confidenceRating: PERCENTAGE;
│ evidenceType: EvidenceType;          evidenceSources: ℙ SOURCE;
│ creator: Actor;                      creationTime: TIME
└──────────────────────────────────────────────────────────
```

A *distillation request* represents a request for making a judgment on a competence of an actor at a given proficiency level based on a set of evidence records.

```
┌─DistillationRequest ─────────────────────────────────────
│ associatedPerson: Person;              associatedEvidenceRecords: ℙ EvidenceRecord
│ associatedCompetence: Competence;      associatedLevel: ProficiencyLevel
└──────────────────────────────────────────────────────────
```

A *competence record*, the result of the distillation process, represents a judgment made by an actor based on certain evidence records at a time point about the associated actor on a certain competence at a given proficiency level. A competence record may be valid or expired. A competence record is more or less reliable.

```
┌─CompetenceRecord ────────────────────────────────────────
│ status: STATUS;                        associatedActor: Actor;
│ associatedCompetence: Competence;      associatedLevel: ProficiencyLevel;
│ confidenceRating: PERCENTAGE;          associatedEvidenceRecords: ℙ EvidenceRecord
│ creator: Actor;                        creationTime: TIME
└──────────────────────────────────────────────────────────
```

There may be many competence records associated with the same actor on the same competence created by the same/different actors at the same/different time based on the same/different evidence records. Individual records are more or less trustworthy and credible. There is a need to fuse relevant competence records to produce an estimate of the competence status, which is more trustworthy and credible than each single competence record. Moreover, competence records associated with different competences, which are related and can be rolled-up as a higher level competence, can be fused as different facets of the higher level competence according to the competence model. A *fusion request* is modeled as below.

```
┌─FusionRequest ───────────────────────────────────────────
│ associatedActor: Actor;                associatedCompetenceRecords: ℙ CompetenceRecord
│ associatedCP: CompetenceProfile;
└──────────────────────────────────────────────────────────
```

So far we have specified the important concepts as data types in Z notation. In the next section, we describe the design of the abstract system model.

3 An Integrated Competence-Based System

A *community* consists of a set of actors which is divided up in persons, institutions, and software agents. In a community, a person could be a friend of another person.

Community

persons: $\mathbb{P}$ Person; institutions: $\mathbb{P}$ Institution;
softwareAgents: $\mathbb{P}$ SoftwareAgent; actors: $\mathbb{P}$ Actor;
isFriendOf: Person $\leftrightarrow$ Person

---

ran institution = institutions $\wedge$ **ran** softwareAgent = softwareAgents $\wedge$
ran person = persons $\wedge$ (**dom** isFriendOf $\cup$ **ran** isFriendOf) $\subseteq$ persons
$\langle$persons, institutions, softwareAgents $\rangle$ **partition** actors

A *learning management* subsystem is specified within the community, in which actors create units of learning, units of assessment, and units of task. Persons can perform and rate them (e.g., quality, easy and difficult). As we can see, this is a self-organized learning environment.

LearningManagement

Community
createUoL: Actor $\leftrightarrow$ UnitOfLearning; takeUoL: Person $\leftrightarrow$ UnitOfLearning
createUoA: Actor $\leftrightarrow$ UnitOfAssessment; takeUoA: Person $\leftrightarrow$ UnitOfAssessment
createUoT: Actor $\leftrightarrow$ UnitOfTask; takeUoT: Person $\leftrightarrow$ UnitOfTask
rateUoL: Person $\times$ UnitOfLearning $\nrightarrow$ RATING
rateUoA: Person $\times$ UnitOfAssessment $\nrightarrow$ RATING
rateUoT: Person $\times$ UnitOfTask $\nrightarrow$ RATING

---

dom createUoL $\subseteq$ actors $\wedge$ **dom** createUoA $\subseteq$ actors $\wedge$ **dom** createUoT $\subseteq$ actors
dom takeUoL $\subseteq$ persons $\wedge$ **dom** takeUoA $\subseteq$ persons $\wedge$ **dom** takeUoT $\subseteq$ persons
ran takeUoL $\subseteq$ **ran** createUoL $\wedge$ **ran** takeUoA $\subseteq$ **ran** createUoA $\wedge$
ran takeUoT $\subseteq$ **ran** createUoT

In the *employment management* subsystem, institutions post jobs; persons can apply for jobs. All information about which person got which posted job and which institution accepted which job applications is captured.

EmploymentManagement

Community
postJob: Institution $\leftrightarrow$ JobPost; applyJob: Person $\leftrightarrow$ JobApplication
gotJob: Person $\leftrightarrow$ JobPost; acceptApplication: Institution $\leftrightarrow$ JobApplication

---

dom postJob $\subseteq$ institutions $\wedge$ **dom** applyJob $\subseteq$ persons
dom getJob $\subseteq$ persons $\wedge$ **dom** acceptApplication $\subseteq$ institutions
ran gotJob $\subseteq$ **ran** postJob $\wedge$ **ran** acceptApplication $\subseteq$ **ran** applyJob

The *competence profile management* subsystem is responsible for the management of information about evidence records, competence records, competence profiles and confidence rates. When a person 'takes' a unit of learning/assessment/task, the system will create an evidence record. The performance information and products (e.g., articles, designs, responses to questionnaire) will be captured and wrapped in the evidence record automatically. Persons are allowed to provide evidence records to include external evidence sources. On demand distillation request with a set of evidence records will be created and published. Relevant actors, which have sufficient competences and interests, can receive and respond to the request and create a competence record according to the distillation request. Then, the system will fuse relevant competence records to produce an estimate of the current competence state of the associated person according to the confidence rating of the records and the reliability of the associated person timely or on demand. Meanwhile, the system will evaluate the confidence rating of each competence record and evidence record, and update the confidence rating based on the current estimate. Finally, the reliability of a relevant person may be updated according to his/her behaviours on providing, assessing, and distilling evidences.

CompetenceProfileManagement

CompetenceModel;
Community;
LearningManagement
learningOutcome: takeUoL $\rightarrow$ EvidenceRecord;
assessmentOutcome: takeUoA $\rightarrow$ EvidenceRecord
performance: takeUoT $\rightarrow$ EvidenceRecord;
provideEvidence: Person $\leftrightarrow$ EvidenceRecord
createDistillationRequest: Actor $\leftrightarrow$ DistillationRequest
distillation: Actor $\times$ DistillationRequest $\twoheadrightarrow$ CompetenceRecord
createFusionRequest: Actor $\leftrightarrow$ FusionRequest;
fusion: FusionRequest $\twoheadrightarrow$ CompetenceProfile

---

dom provideEvidence $\subseteq$ persons; **first** (**dom** distillation) $\subseteq$ actors
dom createDistillationRequest $\subseteq$ actors $\wedge$ **dom** createFusionRequest $\subseteq$ actors
$\forall$ p: Person; l: UnitOfLearning; e: EvidenceRecord | (p $\mapsto$ l) $\in$ takeUoL $\wedge$ ((p $\mapsto$ l) $\mapsto$ e) $\in$ learningOutcome $\bullet$ e.owner = p $\wedge$ e.associatedCP = l.objectives $\wedge$ e.creator = system $\wedge$
($\exists_1$ r:DistillationRequest $\bullet$ (system $\mapsto$ r)$\in$ createDistillationRequest $\wedge$ r.associatedPerson=p $\wedge$
r.associatedCopetence $\in$ l.objectives $\wedge$ r.associatedEvidenceRecords = e);
$\forall$ r: **ran** createDistillationRequest $\bullet$ r.associatedEvidenceRecords $\subseteq$
(**ran** learningOutcome$\cup$**ran** assessmentOutcome$\cup$**ran** performance$\cup$**ran** provideEvidence);
$\forall$ a1, a2: persons; r: DistillationRequest; c: CompetenceRecord |
(a1 $\mapsto$ r) $\in$ createDistillationRequest $\wedge$ ((a2, r) $\mapsto$ c) $\in$ distillation $\bullet$
c.owner = r.associatedPerson $\wedge$ c.creator = a2 $\wedge$
c.associatedCompetence = r.associatedCompetence $\wedge$
c.evidenceSources = r.evidenceSources;
……

The main design ideas have been described above. Because an operation described in Z is specified by presenting the changes in the state space, the implementation method is not explicitly specified. Especially in our model, the processes such as how to distilling and fusing competence information are open questions. We will not describe operations. For a better understanding of the system and problems, we present a highly simplified scenario, which presents some dynamic behaviors of the system from the perspectives of the users.

John, an unemployed civil engineer and a frequent user of the system, uses the system for seeking job offers. After login he sees a 3-dimensional competence space, which consists of three axes corresponding to three main civil engineering competences (structural design, construction physics, and building material). According to his proficiency levels of these competences, his competence profile is represented as a specific point (displayed as an icon) in the competence space. John controls the view by selecting the job offers and the screen shows only the points representing jobs. The distance between the points in this space represents the similarity of the competence profiles. Presumably, John can get basic and more detailed job information by clicking on the job icon. Unfortunately, there are no suitable job offers around his icon. Then he clicks to include the job applications in the competency space so he sees a number of persons' icons around his icon, meaning that many candidates with quite comparable competences are looking for a job in the same area. He decides to explore jobs in a larger scope and finds a cluster of (valid and expired) job posts. These are jobs for energy consultants. He browses and reads the tasks described in the job posts and finds them very interesting. The average salary is acceptable and the geographical locations of several job posts are near his location. He compares the distance between his icon and the cluster of job icons and he concludes that his competences on structural design and building material are sufficient, but his proficiency level on construction physics is below acceptance. Then he decides to check what other competences are necessary for a job as an energy consultant. He shifts to the competence space consisting of axes corresponding to the main competences for this particular profession.

Now he can see his competence profile icon in the new competence space for energy consultants. He observes that the main competence he lacks is financial support. Then he clicks on the button for searching learning activities and the results will be presented as directed lines in the competence space. He can control parameters such as costs, time and preference using sliders in the UI; the learning activities displayed in the competence space will change (e.g., in colors, pattern, style and etc) accordingly. He can also directly manipulate the icons to compare alternatives. After some deliberations and experimenting he chooses several courses and training programs, which show up as a route from his icon to the cluster in the competence space and he saves this as a competence development plan.

After some months of study following the plan, he decides to assess his progress and therefore he clicks the button to present tasks that are surrounding his icon. He chooses a task icon in between his icon and the cluster, about thermal isolation. The selected task is an authentic case and is associated with the jobs for an energy consultant. After having performed the task, he creates and publishes a distillation request with a collection of evidence records produced when he performed the task. The system will check who have recently done the same or similar tasks or are developing the same competence with a comparable level. Then the system sends an internal message to them.

Julia receives an internal message with John's request. Recently, she applied for an energy consultant job. The system checked whether she has qualified levels of all required competences for the job. It found that her competence record on thermal isolation has expired and the confidence rating of this record is low. An online assessment has been suggested to Julia. Now the system sends her an email with John's distillation request. She knows that she has to demonstrate that particular competence by providing additional evidence. She reads the materials (the task done by John and associated evidence records) and fills in the assessment form regarding John's proficiency level on thermal isolation. She judges John's solution is not good enough and rates his competence proficiency level is 3.2. However, because her current competence record on thermal isolation is expired, the confidence rate of her judgment is rather low. The system is currently working with two threads to handle this case. The first one is to collect all John's competence records on thermal isolation and fuse these to produce an estimate of this competence. At the same time the system creates a distillation request after Julia finishes the assessment. John receives this request and judges Julia's level on the same competence as 6.2. However, the mean of all judgments about Julia's level is 5.1. The confidence rate of this competence record is low (28%) because there are no real experienced persons involved in the distillation and there are many deviations like John's 6.2. However, almost all judgments about John's level on thermal isolation are consistent and the fusion result is 3.1. The confidence rate of this competence record is 85%, because almost all judgments ware made by people with competence levels higher than his one. The deviation of John's judgment about Julia reinforces the estimate of the system that his level is not high. When the employer concedes Julia's application, the system shows that the confidence rate of Julia's competence on thermal isolation is not high although the proficiency level (5.1) is acceptable. The employer asks Julia to take a formal assessment on it. John is informed by the system that his level on thermal isolation is insufficient for a qualified energy consultant. He will look for learning activities starting from this level.

4 Challenges

Developing a system as described meets with a formidable set of obstacles, all of which need to be removed before it can be used in practice. Apart from other problems (e.g., on sociability, privacy, and security), there are many technical problems. In this paper, we restrict ourselves to the three main technical challenges.

Producing accurate and reliable competence information: Individual actors' judgment and representation of competences will likely not be accurate and complete, resulting into unreliable information [9]. In our model the attribute 'confidence rate' is used to represent the reliability of competence profile items, actors, evidence records, and competence records. However, it is an open question how to produce appropriate estimates of competences from large amounts of information coming from different sources and different types of sources, which may be inconsistent. Information fusion may be a promising solution to solve this problem. Information fusion aims at achieving improved accuracies and more specific inferences that could not be achieved by the use of any single source alone [5]. It has been applied in many domains such as defense, robotics, medicine, and weather forecast. Competence information fusion is more challenging because the "sensor" is usually human being.

Supporting complicated decision-making processes: The process of decision making implies planning of a professional career, the determination of learning goals and learning needs, and selection of the best course of activities to achieve the goal within certain constraints (e.g., preferences, ratings, cost, and time). Such decision is made by a lifelong learner on the basis of logical analysis of facts coupled with his or her knowledge of the decision-making environment/context as well as his or her experience. As this is a complicated process, it involves repeated consideration of feasible alternatives using multi-criteria with regard to action, their evaluation, comparison and, ultimately, selection of the best solution. The decision making process is thus iterative, integrative and participative. How to apply decision support techniques to support lifelong learners is a challenging research issue.

Development of spatial index and browsing structures and visualization of competence information objects: In our model all competence-related objects can be characterized with one or two competence profiles. Each competence profile consists of several competences with proficiency levels ranged from zero to eight. Thus, a multi-dimensional competence space can be defined. The dimensionality of the competence space consists of axes that correspond to individual competences. Competence-related objects like persons, jobs, and units of learning can be represented as points, hyper-cubes, and directed lines in the multi-dimensional space. By presenting competence-related information objects visually and allowing interaction through direct-manipulation, the learner can traverse competence space rapidly and intuitively. Even if some objects are not accurately described and can not be exactly matched, the learners can browse interesting objects within an area. The combination of visualization of competence-related objects and decision support mechanisms make it possible to provide an interactive and recursive problem solving environment in which the learner proceeds by multiple passes, making use of his own experience, knowledge, and intuition. In order to achieve this goal, we have to take the challenges to reduce dimensionality, build spatial indexing structures and browsing structures, and visualize competence-related objects in dimensional spaces.

5 Conclusions

Competence-based systems serve as a critical medium in many competence-related or competence-driven business processes. They provide management with information and services necessary to make and support decisions. In this paper we propose to extend the concept of a Learning Network by integrating employment management. The importance and benefits of such an integrated lifelong learning and employability support system have been discussed. An abstract conceptual model has been developed and the design ideas have been presented using Z notation. The abstract conceptual model addressed the problems of incomplete and inaccurate competence information and uncertainties of criteria and decision logics. It provides a basis for further analyzing problems, identifying requirements, and developing detail designs.

There is a long way to go for a realization of the target system. Apart from organizational and social problems, we have to face, minimally, three significant technical challenges: 1) to produce accurate and reliable competence information by fusing a large amount of data coming from different sources and different types of sources, 2) to support complicated decision-making processes, and 3) to reduce high dimensionality, develop competence specific indexing structures and browsing structures, and visualize competence-related information in dimensional spaces. The possible technical solutions for these challenges are indicated in the paper.

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Strengthening Web Based Learning through Software Quality Analysis

Juan Manuel Montero, Ruben San Segundo, Ricardo De Cordoba, Amparo Marin de la Barcena, and Alexander Zlotnik

Grupo de Tecnologia del Habla, DIE, ETSIT, Universidad Politécnica de Madrid, Avenida Complutense nº30, 28040 Madrid, Spain
juancho@die.upm.es, lapiz@die.upm.es, cordoba@die.upm.es, amarin.alumno.ie@gmail.com, alexander@zlotnik.net

Abstract. The Web is changing the way people access & exchange information. Specifically in the teaching & learning environment, we are witnessing that the traditional model of presence based magisterial classes is shifting towards Web Based Learning. This new model draws on remote access systems, knowledge sharing, and student mobility. In this context, pedagogical strategies are also changing, and for instance, Project- Based Learning (PBL) is seen as a potential driver for growth and development in this arena. This study is focused on a PBL oriented course with a Distributed Remote ACcess (DRAC) system. The objective is to analyze how quantitative methods can be leveraged to design and evaluate automatic diagnosis and feedback tools to assist students on quality-related pedagogical issues in DRAC enabled PBL courses. Main conclusions derived from this study are correlation-based and reveal that the development of automatic quality assessment and feedback requires further research.

Keywords: Project Based Learning, Software Quality Analysis, Remote Access.

1 Introduction

Although there is no-one accepted definition for PBL, a standard one defines PBL as a *systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks* [1]. PBL is becoming an important educational approach to help faculty improve student outcomes and there are several examples of the PBL technique successfully applied in both pre-university [2] [3] and university courses [4] [5]. In university teaching it has been applied to an ample variety of disciplines including science, arts, business & entrepreneurship education, law, medicine [6] [7] [8]; but most applications have been in technical and engineering courses [9] [10] [11] [12].

In PBL oriented courses, students' and instructors' focus shifts to cover not only functional but also non-functional quality aspects. Over the last few years, there have been several works towards developing automatic tools for supervising and evaluating

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student work as well as facilitating feedback [13] [14] [15] [16]. It is expected that as instructors measure students' performance and provide them with mid-course feedback, supported by automatic diagnosis and supervision tools, students will improve their non-functional skills (e.g. developing high quality software). Moreover, student performance measurement and making feedback available to remote access students will also contribute positively to the development of web based learning.

2 Description and Context of the Course

Analyzed data proceed from and relate to the LSED course (Laboratory of Digital Electronic Systems), which is taught by the Department of Electronics Engineering at the Telecommunications Engineering School of the Polytechnic University of Madrid (UPM). The course's main objective is to serve as a practical approach to the key phases involved in the development of a digital electronic system prototype (including Hardware (HW) and Software (SW) based on a MC5272 ColdFire microcontroller. In modern engineering education, remote access is becoming increasingly important to cope with students' demand for more web based access tools that allow them to use an integrated development environment from their homes instead of having to attend physically to the laboratory.

The implementation of a PBL oriented remote on-line based laboratory entails several difficulties and might require expensive and/ or specialized equipment. Therefore, the approach towards enabling remote access in the LSED is a Distributed Remote ACcess (DRAC) system mainly consisting on a web-based portal that provides simultaneous access to software and hardware resources for several students. [17]. The system was designed to be applicable to certain subjects related to microcontroller programming and digital electronic design with a great emphasis on multidisciplinary interactive applications. A cost-effective mashup approach was followed through the use of several open source technologies. These technologies are not designed for interoperability and are combined in a single system using the best of their individual features. The main implementation problem was the classical one in this kind of system: glue logic. [18]

LSED is a laboratory with a high students-to-faculty ratio and attended by ~400 students every year, but only a minority is aware of the DRAC's capabilities. Students, grouped in couples, have to design, build, test and document a complete microprocessor-based system (both HW and SW) and, at the end of the course, they are evaluated based on a written final report, and an oral examination, which mainly serves to verify that the prototype meets the specifications, check the quality of the software and determine students' ability to explain the obtained results. There are detailed evaluation forms which are filled by the instructors, and in the end students obtain a grading score ranging in a 0-100 scale.

Instructors, at the laboratory sessions, teach students not only the microprocessor's capabilities and some practical implementation issues, but also a systemic point of view, involving multi-disciplinary knowledge: communications, control, user interfaces, etc. This provides a competitive advantage to students who physically attend the laboratory over remote access students, and thereby the interest on software quality analysis to develop web based tools that contribute to reduce that gap.

3 PBL, a New Pedagogical Approach

Assessment, student centered, collaboration, real world connection, extended time frame and multimedia are considered key levers of the PBL approach.

It is a common trend that students and instructors, when dealing with a project which combines hardware and software, focus on the functional aspects setting aside non-functional skills such as developing high-quality software. Nevertheless instructors have started to realize the importance of these non-functional skills and the contribution of PBL techniques in this sense. These allow, not only to grade in a more accurate and comprehensive way by devoting importance to a broad set of components, but also to measure software quality in order to provide students with mid-course feedback on how to improve their software.

Although it is not easy to provide a precise definition of software quality, experts classify software programs in terms of quality based on two non-functional aspects:

- a better code structure and documentation, which makes programmers more lean and agile to undertake complex projects, at a lower effort and including more functionalities.
- an efficient and smart use of data structures, which adds flexibility to the solutions, whilst leading to more elegant algorithms.

Our proposed approach consists on evaluating software quality through quantitative methods based on a two-step process:

- Feature extraction: to quantify those features that could be related to high-quality software.
- Feature analysis: to assess the relevance of the features used in terms of impact on the final grade studying the correlation and mathematical patterns involved.

The outcome of the feature extraction and analysis applied to data from a given academic year could be taken as a reference to set the target objectives in the following years.

4 Analysis of Software Quality Features

This study focuses on a 65-student sample space. For each of them we know the final grade which considers some objective criteria (fulfillment of technical specifications) and a subjective component based on non-functional parameters such as flexibility, tolerance or intelligibility, among others. The objective is to identify code-quality parameters with significant influence on LSED students' final grades as a mean to develop a grade/ performance predicting tool.

A Feature extraction

16 variables have been defined, analyzed and grouped in two categories (Table 1)

- Code structure and documentation: including number of subroutines and their average length, average number of exit points per subroutine, number of commented lines, etc.

- The use of data structures: this includes the use of arrays, global variables, constants, tables, messages, etc.

As students have several degrees of freedom in the design phase, some of the variables have been normalized by the number of code lines with the aim of making them more comparable and avoid favoring longer programs. Variables were collected through a C code analyzer and afterwards introduced in a spreadsheet application for the purpose of analyzing the collected data.

Table 1. Variables' categorization and main values

Catego	Variable	Comments	Rel. mean	Rel Pear-son	Abs. mean	Abs. Pear-son
Code structure & docume-ntation	Number of code lines	Relevant; Apparently, high values signal good students	1,00	N.A.	484,09	0,38
	Number of subroutines	Relevant even after normalizing; high values apparently signal good students	0,06	0,30	30,69	0,43
	Number of exit points per subroutine	Low relevance and negative contribution; can be reduced	0,01	-0,08	1,64	-0,08
	Mean subroutine length	Negative impact; can be reduced (area for improvement)	0,07	-0,23	22,40	-0,22
	Length of the longest subroutine	Irrelevant; can be reduced	0,19	-0,30	67,29	0,04
	% commented lines	Negative after normalizing; should significantly increase	0,22	-0,10	68,53	0,16
Data structures	Number of Loops	Relevant even after normalizing; indirect complexity indicator	0,05	0,20	21,92	0,50
	Number of IFs	Almost relevant after normalizing; indirect complexity indicator	0,11	0,13	49,11	0,36
	Number of lines with [ ]	Negative after normalizing; apparently high	0,23	-0,10	110,71	0,22
	Number of strings / messages	Relevant even after normalizing; apparently high	0,13	0,23	58,22	0,52
	Number of GOTOs	Fortunately nobody has used them	0,00	0,00	0,00	0,00
	Number of STRUCTs	Nobody has used them; they should be more used	0,00	0,00	0,00	0,00
	Number of MACROS	Scarcely used; should be more used	0,00	0,22	0,28	0,25
	Number of INCLUDEs	Relevant even after normalizing; should be more used	0,02	0,32	7,83	0,45
	Number of DEFINEs	Relevant even after normalizing; should significantly increase	0,05	0,30	21,12	0,51
	Number of TYPEDEFs	Low number of cases; should be more used	0,00	0,21	0,32	0,19

B Feature analysis

For the target variables included in our study, the average (MEAN function), standard deviation, maximum and minimum values and the Pearson correlation coefficient were calculated. Given the final grades for each student and their correlation with the

Table 2. Criteria to assess features' relevance on grades predicting

Correlation	Negative	Positive
Small	$-0.3 \leq \rho_{x,y} \leq -0.1$	$0.1 \leq \rho_{x,y} \leq 0.3$
Medium	$-0.5 \leq \rho_{x,y} \leq -0.3$	$0.3 \leq \rho_{x,y} \leq -0.5$
Large	$-1.0 \leq \rho_{x,y} \leq -0.5$	$0.5 \leq \rho_{x,y} \leq 1.0$

selected quality variables, the goal is to assess the relevance of each feature on the final grade.

The correlation coefficient is a value ranging between [-1, 1]. Two variables are said to be non-correlated when their correlation coefficient is null; for the purpose of this study, the relevance of the features analyzed for grades' predicting is subject to specific criteria (Table 2.) Additionally, when the absolute value of the correlation is close to 0, it is assumed that the feature is not relevant to predict students' grades.

A first comprehensive analysis of the selected variables' Pearson coefficient was conducted, considering the overall students sample; this revealed that none of the selected variables' Pearson was high enough to classify it as decisive to predict students' grades. Most of the variables showed a small or medium correlation and only the use of strings/ messages, and the use of DEFINEs surpassed the threshold of large correlation variables. (Fig. 1.)

Nevertheless, results after normalizing showed a different picture, revealing that the use of optimized subroutine lengths was the most correlated normalized variable to students' grades. (Fig. 2.)

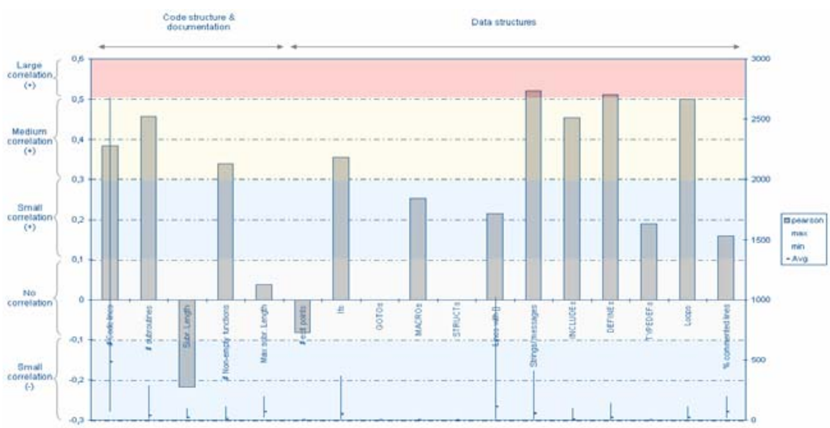

Fig. 1. Analysis of selected variables

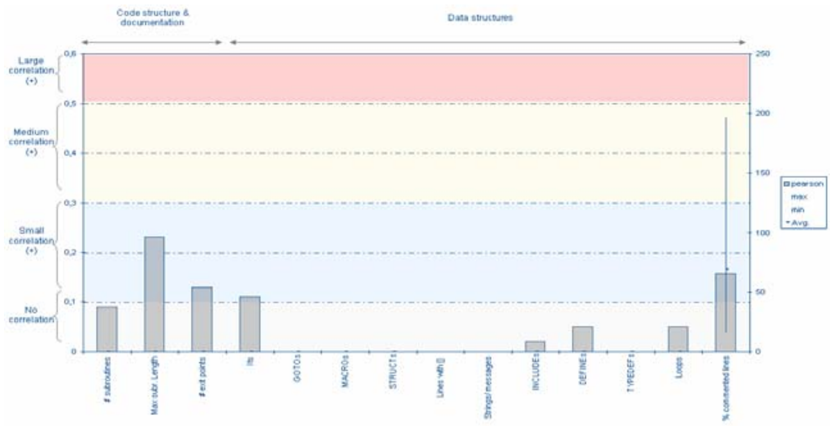

Fig. 2. Analysis of selected normalized variables

Table 3. Criteria to assess features' relevance on grades predicting

Segment	Description	% over total
Top performers	Students whose grade is ≥ 100.0	20%
Average	Students whose grade is ≥ 75.0 but < 100.0	35%
Low performers	Students whose grade is < 75.0	45%

As a next step, in order to get a deeper understanding of the results, the 65 students sample was segmented into 3 groups (Table 3.)

For each of the groups, the Pearson coefficient, mean, maximum and minimum values, and the standard deviation were analyzed. The outcome of this analysis confirmed that features related to data structures have a higher impact on students' grades than those related to the structure and code documentation, but as students get more experienced, these latter features become more important, increasing their weight from 26% in the group of lower performers to 42% in the group of top performers. (Fig. 3.)

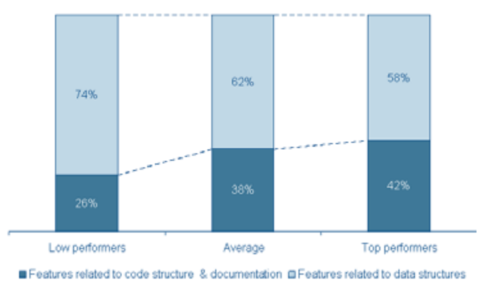

Fig. 3. Weight of the different variables per student segment

From the compilation of the results derived from the various analyses conducted the following highlights have arisen in the features analyzed:

Features related to the structure and code documentation

- Number of lines of code (avg. 484, Pearson 0.38): the volume of lines of code is apparently advantageous for the grade, as it enables to create more complete algorithms (Top performers (752 lines) vs. Low performers (319 lines)). However, it is observed that for those students who have achieved a reasonable advanced level, more code lines often result in more confusion and space to commit mistakes. Hence, advice aimed to students in this regard should be to look for code optimization, producing more compact and better readable algorithms.
- Number of subroutines (avg. 31, relative Pearson 0.3): the number of functions is related to the scope of the program's functionality; increasing number of functions enables increasing system's functionalities and avoids excessive length of code blocks, which difficult programs' tracking and reveal that there is a flaw in the design phase. (Top performers (58 subroutines) vs. Low performers (17 subroutines)).
- Number of exit points per subroutine: The structure of subroutines is also relevant: they should be non-interlaced (non-overlapped) and with just one exit point or return instruction per function. (Current average is around 1.6)
- Mean subroutine length: represents the average size of students programs' functions. Its Pearson coefficient in absolute terms is negative (-0.22) signaling that long functions are not a good programming practice to achieve a good grade. On the contrary, smaller and more specialized functions make better programs, easier to analyze and debug. (Students achieving the best grades use a below average number of lines per subroutine (17 vs. 23)
- Length of the longest subroutine: it is measured in number of code lines and after normalizing its Pearson coefficient is -0.30. However, taking into account the Pearson per student segment, it is worth highlighting that this parameter achieves a significant value (0.46) for the average students segment. Consequently we can infer that the length of the longest subroutine is positively correlated with the grade until students reach a certain knowledge level. At that point they understand the importance of code optimization and thus the Pearson coefficient turns negative.
- Number of commented lines (absolute Pearson 0.16): is considered in relative terms, as a % of total code lines (68.5% on avg.). Most commented programs are not necessarily the best graded, as students with the longest programs tend to focus on including more functionalities without paying the same degree of attention to keeping comments at such high level.

Features related to the use of data structures

- Number of loops and IFs: the use of unconditional and conditional jumps, which is related to loops and if-then-else structures, adds complexity to the programs; a high number of functions implemented is an indirect indicator of complexity; the most complex programs have more but shorter local jumps, limited by the size of the subroutines. Underscore that the Pearson coefficient of loops after normalization reaches 0.20.

- Number of complex data structures: linked to the use of arrays which allow more compact and smarter algorithms (number of lines with []) and messages (warning, error) for a better user interface (number of strings/ messages). The relevant feature here is the number of strings, which after normalizing shows a Pearson coefficient of 0.23. On the other hand, the number of lines with [] is negatively correlated (-0.10) after normalizing this feature, which leads to infer that after a certain point, the use of additional complex data structures may difficult the reading of programs and thus contribute negatively to the grade.
- Number of GOTOs: often considered as a bad programming practice; fortunately no single use case has been described.
- Number of STRUCTs and MACROs: the use of these commands is an indicator of advanced knowledge programming level. Unfortunately, STRUCTS, which are elegant data structures, were not used by the students
- Number of INCLUDEs, DEFINEs and TYPEDEFs: ease the access to complex data structures such as tables or lists, which are indeed related to a more elegant programming style, revealing in many cases higher quality software. Specifically in the case of INCLUDEs, the normalized Pearson coefficient is in the range of [0.23 – 0.30]. Moreover, the use of DEFINEs has more weight as students acquire more advanced programming skills.

5 Results Assessment

From the data analyzed, several areas of improvement have been identified; in this regard, the proposition of specific targets and initiatives should help achieve students' software quality enhancement and new learning objectives in the following courses:

- In the assignment's introductory text, include both general and specific recommendations and examples of good coding practices
- Define quality rules of thumb to guide students:
  - The longest subroutine should not exceed 50 lines
  - Average number of subroutines should be above 25
  - Average subroutine length should be below 20 lines
  - 95% of the subroutines should have just one exit point
  - 30% of code lines should include comments
- Develop automatic web-based diagnosis tools to provide mid-course student feedback, early detection of bad programming habits and deter students from plagiarism.

In terms of the weight of quality features on students' grades, the number of subroutines, the use of strings / messages, and the use of complex structures has a positive impact on students' grades showing positive correlations above 0.4. Additionally, as instructors emphasize on code optimization and program documentation aspects, it is expected that variables such as the mean subroutine length and the % of commented lines will become increasingly important.

The present analysis has also served instructors to identify concepts that students have not yet fully assimilated:

- Number of exit points per subroutine should be ideally 1: most top performers are close to attaining this, whereas the average is around 1.6
- Use of commands and complex data structures: (e.g. STRUCTs, MACROs, INCLUDEs) these can be very useful, but there is a low number of examples on students' programs.

Conclusions and findings can be used as the basis not only to orientate students on their performance compared to the rest of their classmates on that year, but also to provide students some advice and guidelines which have been helpful to others in similar circumstances; i.e. to build-up a continuous learning process based on past experiences.

6 Conclusions

This paper has presented an analysis of 16 selected code quality parameters in the context of a PBL remote access course. The objective was to identify key variables that could influence students' programming behavior and thus, to what extent these could have an impact on students' grades. Results derived from this analysis are based on a 65 student sample and therefore, should not be considered as statistically relevant, though useful to identify and understand certain trends. Main conclusions and findings reveal that none of the variables selected had a determinant impact on student's grades (with correlations < 0.55). For instance, although the number of strings/ messages, considering the whole students sample, showed the highest Pearson coefficient (0.52), if the sample was segmented based on students' performance, both the most correlated variable and the degree of correlation may vary per category (Top Performers, Number of Macros (-0.44); Average Performers, Number of Strings/ Messages (0.51); Low Performers, Number of IFs (-0.37)).

One key concern related to the use of a correlation-based analysis is that if features are correlated amongst them, and one feature shows a significant correlation, the remaining features will also show correlations in line. In this regard and to isolate this effect, we have conducted a recursive multi-phase analysis: For each iteration, the highest correlated variable was identified and, in the next phase, all variables were normalized with respect to the most correlated variable. For the purpose of this study after two iterations were completed, the number of strings / messages (1^{st} iteration) and the length of the longest subroutine (2^{nd} iteration), resulted the most correlated variables (Pearsons of 0.52 and -0.44 respectively).

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User Evaluation of a Graphical Modeling Tool for IMS Learning Design

Susanne Neumann and Petra Oberhuemer

University of Vienna, Center for Teaching and Learning, Porzellangasse 33a, 1090 Wien, Austria
{susanne.neumann-heyer,petra.oberhuemer}@univie.ac.at

Abstract. IMS Learning Design is said to be highly technical language that is hard to understand and apply by teaching practitioners. The modeling tool Graphical Learning Modeler was built to bypass this problem for level A and partially level B of the IMS Learning Design specification. Its graphical interface with drag and drop allows easy setup of learning designs that can be made conformant to IMS Learning Design. This article presents the results of an evaluation of the Graphical Learning Modeler performed with instructors at a higher education institution. Results showed that instructors were generally successful in building learning designs, but that they still had problems with transferring concepts from their teaching environment to the concepts of IMS Learning Design. Furthermore, they had trouble grasping the meaning of an editor environment that is outside the runtime environment.

Keywords: IMS Learning Design, editor, modeling, graphical, usability.

1 Introduction of the Graphical Learning Modeler

1.1 The IMS Learning Design Specification and Early Editing Software

The IMS Learning Design (IMS LD) specification [1] was introduced in 2003 to offer a counterpart to the regularly content-focused e-learning standards. Its purpose is to describe any pedagogic approach in standardized language for face-to-face as well as online learning situations [1]. Specifically, the language offers to express the actions that persons perform, the different roles they take during activities, as well as the artifacts they use and exchange during those activities. The eXtensible Markup Language (XML) builds the foundation of IMS LD. All needed elements (an imsmanifest.xml that holds the learning design as well as physical files used in the learning design) are captured in a unit of learning package.

The critique so far has been that the language IMS LD offers is hard to understand and that it takes considerable effort to apply [2], [3]. Before software applications for IMS LD editing were available, learning designers had to code in XML to produce units of learning. The Reload Learning Design Editor solves this problem by providing an interface that works without any XML coding. However, the Reload editor still requires its users to know the syntax and semantics of IMS LD, meaning that instructors without this prerequisite knowledge can only create units of learning if they

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receive significant technical support [4]. To overcome this problem, the Graphical Learning Modeler (GLM)[1] was built.

1.2 Development of the GLM

The goal of the GLM development was to offer teaching practitioners an editor that allowed them easy, i.e. without significant prerequisite knowledge, building of an IMS LD conformant unit of learning. This unit of learning, once created, can be imported in any learning management system, which is capable of interpreting IMS LD units of learning. A graphical interface with drag and drop functionalities was implemented in the GLM to allow intuitive modeling. A screenshot of the GLM interface is depicted in Fig. 1.

To reach the goal of reducing instructors' prerequisite knowledge, the GLM hides at level A (basic IMS LD software development level) the time-related control elements *Play*, *Act*, and *Role-Part*, and at level B (advanced software development level) it hides the elements *properties* and *conditions*, which are used to store and monitor data and resources generated by persons participating in the unit of learning.

1.3 Main GLM Functionalities

The largest part of the GLM is the workspace in the middle (cp. Fig. 1), where the learning designer creates the sequence of activities. The design palette in the upper

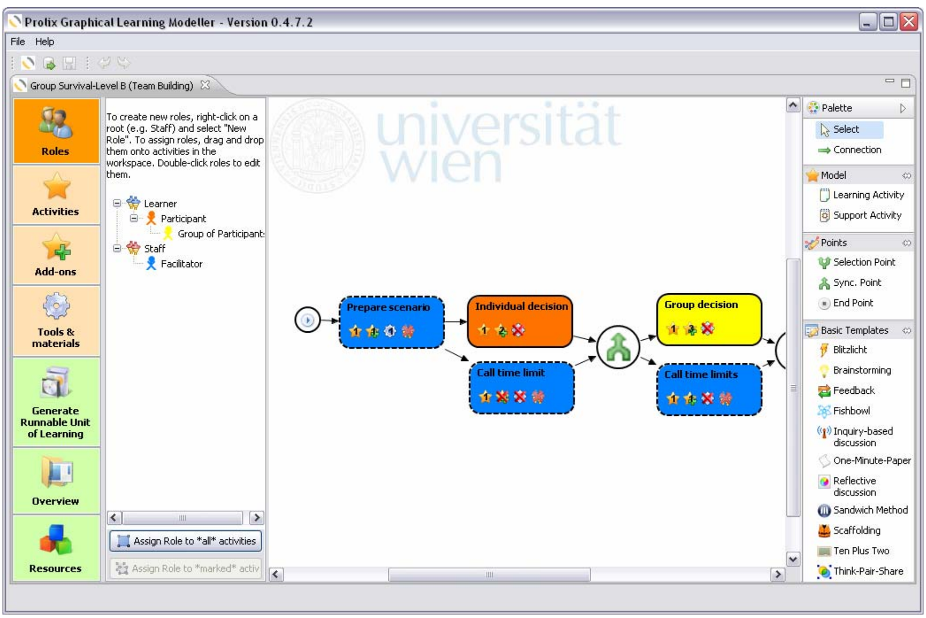

Fig. 1. Total View of Graphical Learning Modeler version 0.4.7.2 (post-evaluation version) depicting navigation menu, instance trees, workspace, and design palette (from left to right)

[1] http://sourceforge.net/projects/prolix-glm/

right corner provides design and altering functions such as the creation of activities, or the drawing of connections between activities. Models (activities) and points for selection or synchronization of activities may be easily dragged and dropped from the palette onto the workspace. A special design area, formerly called *Interactions* now called *Add-Ons*, offers learning designers IMS LD level B functionalities for the integration of design elements that allow interactive contributions of the unit of learning participants during runtime. There are currently four types of Add-Ons available: text work, uploading files, question & answer, and multiple-choice test. The Add-Ons are integrated in the left-hand navigation bar and additionally within each dialog for editing an activity. A context-sensitive help system guides learning designers when applying Add-Ons to activity sequences. In order to enable users to systematically and efficiently manage all required resources, the GLM incorporates a centralized resource management that is accessible via the navigation bar's tab *Resources* (bottom left in Fig. 1). The resource management offers a taxonomical classification schema, which consists of pre-specified categories referring to IMS LD elements that are provided to store all learning design relevant files, e.g. activity descriptions and learning objects. In this way, the resource management facilitates the reuse of already existing resources and provides explicit information about the context a resource is used in.

The GLM interprets the graphically captured learning design from the workspace and automatically detects acts, role-parts and activity structures (bundled activities that are performed by the same role) as well as properties and conditions in order to generate the corresponding imsmanifest.xml. Conditions are needed for more complex learning designs with parallel, independent activity strands performed by several roles: In order to maintain the independence of all roles, level B conditions are used to provide each role access to its activities at the right time.

2 User Evaluation

2.1 Previous Evaluations of the GLM

Feedback during the GLM development was previously collected from three different communities of users: pedagogical experts, PROLIX[2] test bed partners, and IMS LD tool developers. Generally, the feedback was positive; especially the drag & drop functionalities and the quick setup of an entire learning design were well received. However, the different communities also expressed varying wishes for extensions to the GLM.

Pedagogical experts wanted an overarching view on the learning design: The level of design, which in the GLM is represented by activities, was too small for them to plan a semester-long course. This problem was attempted to be partially solved by including ready-to-use learning design templates that cover a longer frame of time so that instructors do not have to start at the activity level. Furthermore, an annotation function is planned for future implementation that will allow the learning designer to comment the design and make connections between different parts of the learning design.

[2] Process-Oriented Learning and Information Exchange (PROLIX), http://prolixproject.org/

PROLIX test bed partners continuously give feedback for all software components used within the project, to which the GLM developments also belong. The international standards ISO 9241-110[3] for guidance principles on the ergonomics of human-system interaction and ISO 9241-11[4] for usability guidance on visual display terminals build the foundation of this evaluation. The feedback showed that controllability of the GLM software, conformity with user expectations, suitability for the task and suitability for learning were positively viewed. Improvements were especially recommended for error tolerance, i.e. supporting the learning designer to recover from errors. Results for the late 2007 and late 2008 evaluation can be seen in Fig. 4.

IMS LD tool developers were the third community that gave feedback during early GLM development. Again, the feedback was generally positive as indicated by the positive values the developers rated on the structured feedback form. The critical comments regarded specific IMS LD features that the tool developers were missing in the GLM. This feedback has to be viewed in the light that novices are the target audience of the GLM. Therefore, not all functionalities of IMS LD are offered in the GLM, even some of the main concepts like *plays* or *acts* are hidden from users. It is therefore hard to integrate functions for elements that are not even visible within the GLM, for instance, controlling how an act is ended. Some criticized that even though the GLM attempts to hide the IMS LD concepts, it still contains too much visibility of these elements in the software. In further developments, we integrated this feedback.

More details on previous evaluations can be found in [5].

2.2 Method

A principal evaluation was then planned, especially with the purpose to collect feedback from the audience that had originally been the target group of the GLM development: teaching practitioners, who are not knowledgeable of the IMS LD specification. The goal of the evaluation was to test the usability of the GLM version 0.4.6, to test instructors' ability to create units of learning and their understanding of the IMS LD concepts as represented in the GLM. The applicability of the GLM in the instructors' own teaching context was also of interest during the evaluation.

Test persons were chosen to partake in the evaluation if they were instructors (professor, lecturer, teaching assistant, or trainer) at the University of Vienna. Their age was not considered relevant, although a focus was placed on instructors who have had experience with technology-supported teaching.

The test population eventually comprised 21 test users. They represented a wide range of subject areas (e.g. physics, business administration, theology, geography, social sciences, computer sciences etc.) and judged themselves to have considerable knowledge in the practice of e-learning (on a 1 – 5 continuum, with 5 representing the highest knowledge, test users rated their knowledge at an average of 4.3). The range of test users' general experience of teaching at a higher education institution was between one and twenty years.

There were three separate dates of testing. The difference between the test days was that test users on the first and second day received a ten-minute live demonstration

[3] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=38009

[4] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=16883

about the main functions of the GLM, while test users on the third day watched a three-minute flash video of the main GLM functions. Following a quick round of question-and-answer after the presentation, the test persons had to create two learning designs using the GLM: One design was prescribed, and one design they had to derive from their own teaching context. The prescribed design was presented as a printed narrative less than a page long.

The entire test population was split so that half of the test users started off with the prescribed learning design, while the other half started off with a learning design that was derived from their own teaching context.

Test users kept a protocol while performing the evaluation tasks. In the protocol they recorded the time they started and ended each learning design, any questions that arose while they worked on each learning design, and a yes/no remark whether they were able to resolve each question on their own. When finished creating the learning designs, test users filled in one structured questionnaire using a four-point Likert scale with usability questions and finally answered three open-ended questions.

2.3 Results

The evaluation showed that test users were successful in building the learning designs. Of the 40 learning designs[5] that test users built, 37 were complete or nearly complete. *Complete* means that the learning design had all necessary components to be exported as an IMS LD unit of learning; *nearly complete* means that only a minimal element, like a connection between two activities, was missing to completion. This can be considered a success as the time to introduce test users to the functions of the GLM was minimal, yet sufficient to put them in a position to build complete learning designs. This is true for instructors that watched the live demonstration as well as for instructors, who watched the shorter flash film.

The test users made extensive use of the functionalities offered within the GLM. They used both types of activities offered (learning activity and support activity), set up and assigned multiple roles and even child roles, created environments[6], used level B functions, and built complex learning paths with varying modes and simultaneous activities of different roles.

Despite this success, test users still encountered problems. Fig. 2 shows groups of questions recorded by the test users in their protocols. *Software handling* summarizes questions of the kind, “how do I delete a connection?” or, “how can I copy activities?” *Interpretation of software elements* summarizes questions like, “what is the difference between environments and interactions?” or, “I don’t know what the error messages mean when I try to export the unit of learning.” Examples for *Transfer of teaching concepts into software* include, “how do I enter session times and deadlines?” or, “how do I define a group for learners’ group work?“

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[5] Note that two test users did not attempt to build the *prescribed design*; they just built a design from their own teaching context. These are the two missing learning designs to a total of 42.

[6] Environments are containers for learning objects and learning services such as chat or forum that are used during activities. Once created, an environment can be referenced multiple times within different activities.

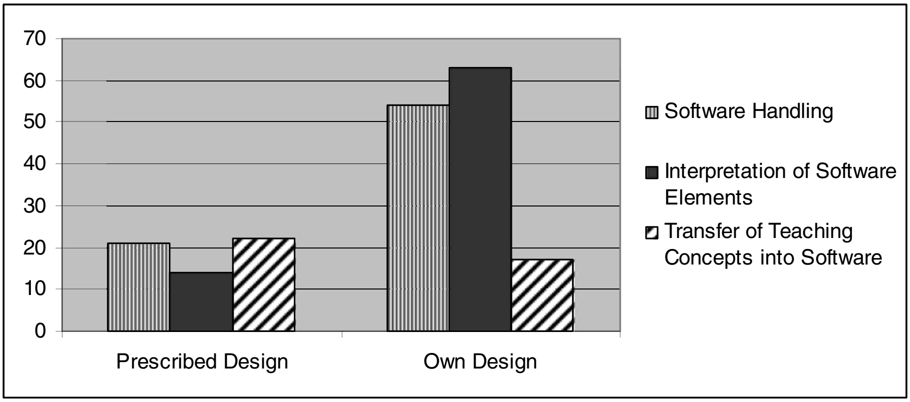

Fig. 2. Number and types of questions recorded by test users during the preparation of prescribed and own learning designs (N=21)

As Fig. 2 shows, test users recorded overall nearly twice as many questions when creating a learning design that was derived from their own teaching context as compared to when creating the prescribed design. Since the test user group was split (half the users started with the prescribed and half started with their own design), this difference in questions recorded cannot be attributed to users starting first with one or the other design. It seems that transferring a teaching situation from one's own context into the GLM is a farther step to take and thus generates more questions with instructors, than when transferring a purpose-built narrative into the GLM. Nevertheless, this did not impede users' ability to complete learning designs as the test users were just as successful in completing or nearly completing their own designs as they were with the prescribed design. Of the questions recorded, test users reported that they were able to solve 23% of questions recorded when working on their own designs, and 30% of the questions recorded during the prescribed learning design.

When giving feedback using the structured questionnaire when they had finished the two learning designs, test users attributed mostly positive values for the GLM, meaning that they found the GLM quite usable. The only critical element, whose average value had a clear negative tendency was, "I understood the concept of the special design elements Interactions." *Interactions* is the overarching term for all available IMS LD level B functions that the GLM offers. Although the GLM packages the complicated technical setups for level B properties and conditions, and presents them to users in a teaching practitioner-oriented terminology (e.g. text work, uploading files), test users clearly indicated that they had trouble using this feature. Major reconstruction for this interface element is thus necessary.

To wrap up the GLM evaluation, test users answered three open-ended questions:

1. To what extent can you imagine an integration of the GLM in your teaching practice?
2. What problems do you see in using the GLM, and why do these problems occur?
3. What suggestions do you have to improve the GLM?

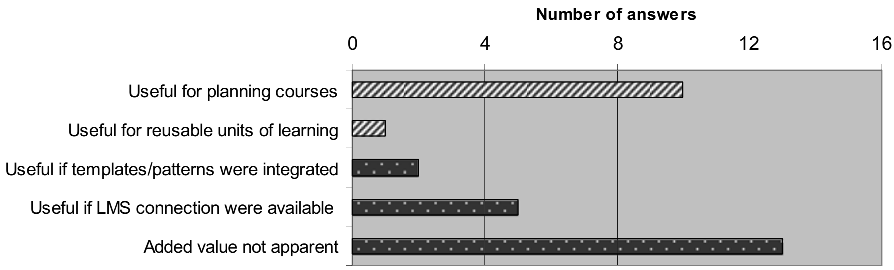

Fig. 3. Free answers given by test users to the question, "To what extent can you imagine an integration of the GLM in your teaching practice?" (N=21)

Fig. 3 shows the most common answers given in response to the first open-ended question. About half the test users answered freely that they find the GLM useful for planning courses. However, more than half of the test users answered that the added value of the GLM was not apparent to them. Others noted that if additional functions such as ready-to-use learning design templates or a connection to a learning management system (LMS) were available, then they would see a possibility to integrate the GLM in their teaching practice.

Questions 2 and 3 aimed to identify problems and areas for improvement. Test users reported here that they would like to see the Interactions improved (which had already been shown in the quantitative analysis of the usability questionnaire). It is praiseworthy that test users were using level B concepts in their learning designs. This may be the first record of instructors without knowledge of IMS LD autonomously using level B functions. Previous reports mentioned that instructors could only create level B units of learning when someone else besides the instructor built the necessary level B components [4]. The instructors taking part in this evaluation had no help and no introduction to level B concepts as these functions were not even part of the minimal introductory demonstration; yet, more than two thirds of them included level B specific functions in their learning designs. After using the level B functions, test users reported that the interface was not intuitive to them, e.g. dragging and dropping artificial sub-steps of a text-work interactive element onto activities in the workspace. They wanted to drag the text work itself, not the sub-step. However, if the setup of level B functionalities as it was represented in the GLM 0.4.6 (the version being tested) was sufficient for test users to understand the concept of interactive elements, then this represents a comfortable starting point for improvement.

Test users further reported that they would like to see improvements of the environments. The concept *environment* as a container that holds materials and services used during activities bewildered the test users. First of all, they confused the environment with the runtime environment, i.e. the LMS. This may stem from the term "environment" usually being used to describe the setting where the learning will eventually take place. Furthermore, the incessant assignment of titles when working with environments (e.g. title for the environment, title for learning object inside the environment, title for the resource that represents the learning object etc.) agitated test users. They did not understand why it is necessary to assign so many titles. This may be due to the fact that the instructors had no visualization of the runtime environment, where it may be more apparent that titles are needed to reference environments, learning objects, and included resources (just like activities) in navigation menus. Finally, some instructors questioned what the difference is between activities and an environment; To these instructors, the two seemed to be integral.

Last but not least, test users noted that a connection from the GLM to a learning management system needs to be made so that they can visualize what they are building in the modeling tool.

2.4 Changes to the GLM as a Result of the Evaluation

The improvement of Interactions has been tackled by redesigning this portion of the GLM. The previous drag and drop functionality was simplified in version 0.4.7 as requested by the test users, and additionally, level B functions were offered within each dialog for editing an activity. This more closely corresponds to the way a learning design with level B functions is built, as these special functions are often directly associated with activities. A wizard that guides learning designers step-by-step through the needed elements for setting up level B functions was integrated for both access options (instance tree and activity dialog). Further, level B functions were renamed from *Interactions* to *Add-Ons* to make clearer to the learning designers that the offered level B functions belong to and thus extend activities through interactive elements.

Reacting to the problems test users encountered with environments, the container that represents the environment was hidden from the user's view in GLM 0.4.7. Instead, users now directly work with learning objects and services as they had requested during testing. This means that learning designers do not have to create the environment container anymore, but every time a learning object or service is being created and assigned to an activity, the GLM automatically creates an environment element, automatically assigns a name to the environment, and references the assigned items within the environment. Again, this design function was renamed to make clearer to users what is meant, since they had confused "environment" with the LMS, where the learning design will be executed. Therefore, environments are now called *tools & materials*.

The wanted integration of the LMS into the GLM cannot be taken care of as part of the current developments as the amount of resources needed for this undertaking is considerable larger than the entire GLM development. It is recognized, though, that the direct connection to a runtime environment or LMS that visualizes the learning design even while being designed is an important feature that would provide tremendous aid to learning designers.

Another request test users mentioned in answers to the open-ended questions was to provide ready-to-use templates. In GLM 0.4.7, a set of eleven templates capturing common teaching methods like brainstorming or discussion exercises have been implemented as a new feature. Now, learning designers can via drag & drop create an entire sequence of activities including all roles and all activity descriptions as well as associated materials.

The changes described above have been implemented in GLM version 0.4.7. PROLIX test bed partners, who regularly test the software, evaluated this advanced version. The results are shown in Fig. 4, depicting two ratings collected at two

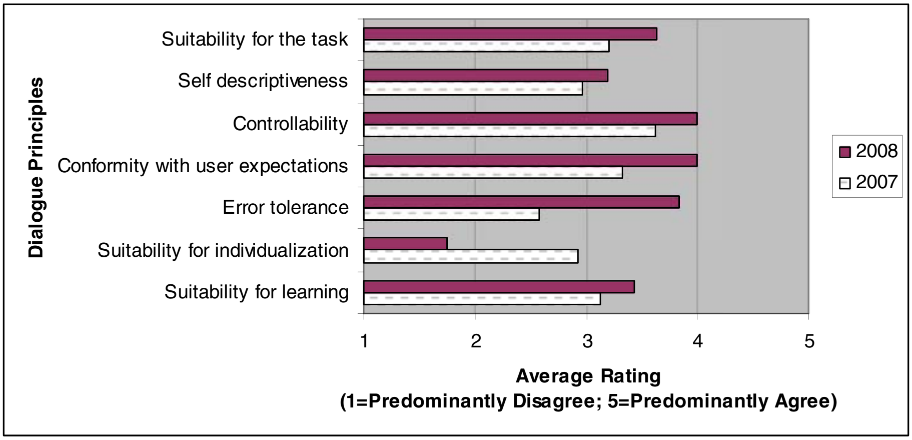

Fig. 4. Average Ratings for GLM versions 0.4.4 and 0.4.7 by PROLIX test bed partners according to ISO human-system interface dialogue principles in late 2007 and late 2008

different points in time, namely in late 2007 (GLM0.4.4) and in late 2008 (GLM0.4.7). The foundation for the evaluation built the ISO human-system interaction dialogue principles mentioned above. As can be seen, significant improvements have been made for all the principles except suitability for individualization. This decline may have appeared because PROLIX test users have become more cognizant of suitability issues during the time of the project, and with this raise in expectations, they did not see a match for them reflected in the GLM.

3 Conclusion

This article introduced the GLM, editing software for IMS LD units of learning. The barriers that IMS LD presents due to its technical focus were aimed to be overcome by designing a graphical modeling tool that allows easy editing of units of learning, even for novices of IMS LD. This goal has to some extent been achieved as the instructors participating in the herein described user evaluation successfully created complete learning designs that could be exported as units of learning. They did so after having watched a minimal demonstration of the main features. There has not been a report for such a short learning time in regard to other IMS LD editors. Another success is that more than 70% of the instructors included level B functions in their learning designs, even though they were not introduced to this feature.

Results of the GLM evaluation showed that there are still improvements necessary. Some of the improvements have already been accomplished like the improved access to level B functions, the hiding of the environment, and the inclusion of ready-to-use learning design templates. Despite test users reporting good usability in their feedback, the added value of the GLM was not necessarily apparent to them. A major reason for this is probably the lack of a connection between the GLM and a runtime environment, which cannot be realized within the current development.

The lack of connection between editor and runtime environment points out a major problem that all IMS LD tool developments essentially have: Creating a unit of learning outside the runtime environment, where the unit of learning will be implemented with learners and instructors, represents a great barrier to the eventual success of IMS LD. Instructors have a hard time creating a learning environment in an abstract manner, away from the place where the unit of learning will eventually be visible to learners. The evaluation showed that instructors would have favored to create their unit of learning directly in the system where it will be implemented. If the concept of keeping editors separate from runtime environments remains, then a smooth bridge between the two has to be built that leaves the learning designer believing that the two software systems (editing and runtime) are homogeneous.

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Challenges for Blog Analysis and Possible Solutions

Anh Vu Nguyen-Ngoc and Effie Lai-Chong Law

Department of Computer Science
University of Leicester
Leicester LE1 7RH, United Kingdom
{anhvu,elaw}@mcs.le.ac.uk

Abstract. Blogs are increasingly used as an educational tool because of their ease of use for web-based publishing, enabling users to share their thoughts that invite intellectual and social discourses. Blogs are becoming a significant component of many web-based learning environments. However, there are 2 major challenges in applying blogs in web-based learning: (i) browsing/searching blog archives are technically not well supported in a learning environment in which several blogs are used by both facilitators and students; (ii) there is lack of a theoretically sound and usable blog analysis scheme to analyse blog content in order to support the evaluation of collaborative learning activities in web-based courses. In this paper, we describe some possible solutions for these challenges based on our research on web-based collaborative learning settings. Our experience of applying blogs in a web-based cross-cultural collaborative learning course is also reported.

Keywords: Blog, Feeding mechanism, Content analysis, Social network analysis, Interaction patterns, Collaborative learning.

1 Introduction

Blog (or Weblog) is a type of website that is usually maintained by an individual with regular entries being commonly displayed in reverse chronological order. Blog has emerged as a popular social software tool in recent years, and blogging (i.e. to maintain the content of a blog) as a web-based form of communication is becoming mainstream [15]. In Higher Education Institutions (HEIs) worldwide, we can witness the broad dissemination and adoption of this tool. This increasing trend suggests that learners tend to circumvent the constraints of centralised authorship [11]. Furthermore, blog meets the need for instant communications in a knowledge-building community [4] because it enables self reflection and student-facilitator as well as peer communications. Indeed, a salient quality of blog is its effectiveness and ease-of-use for publishing one's thoughts that invite further intellectual as well as social dialogues. Blogs provide the space where the decentralised authorship can be realised and create a flexible environment where students can be motivated to reflect and discuss [13]. Being able to engage in sustainable constructive discourses is imperative for motivating students to continuously participate in a web-based learning course.

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With appropriate design and guiding strategies, blogs have great potential to become a powerful tool that supports web-based learning in academic institutions and workplaces [1, 10]. Nonetheless, much research effort is still required to exploit the potential of blogs as an educational technology, for instance, visualising blog-based interaction patterns as feedback for users to regulate their behaviours [2, 9, 18]. Furthermore, analysis of blog messages to evaluate the collaborative learning activities is problematic. Among others, there are 2 major challenges to tackle: (C1) browsing/searching blog archives efficiently and effectively are currently not well supported [3, 9], especially in a learning environment in which several blogs are used by both facilitators and students; (C2) a theoretically sound and practically usable content analysis scheme for analysing blog content in order to support the evaluation of collaborative learning activities in web-based courses is lacking.

We aim to tackle some of these challenges in our project iCamp (http://www.icamp.eu) where the blog has been *heavily* used. The project aimed to create an *open* virtual learning space for HEIs in Europe and to advance learners' self-directed learning and collaboration competences [5]. The validation of these goals was realised through trials or field studies. We adopt mixed methods approach to capture data from different sources and actors to triangulate the findings. In this paper, we report the design and implementation of our recent validation trial (hereafter '**Trial**') in Section 2 where the challenge C1 is addressed. In Section 3, we describe in detail our blog analysis scheme – the challenge C2. Discussions about our trial experience and implications for future research are addressed in Section 4. Some concluding remarks are presented in Section 5.

2 Trial: Settings, Participants and Feeding Mechanism

The Trial was implemented as an international, *fully* online master level course in the spring semester 2008 (March – June). It was an introductory course on "e-learning course design". Pedagogically, it was grounded in the social constructivist learning theories with the aim of advancing the learner's competences in self-directed learning, social networking, and cross-cultural collaboration through individual as well as group learning activities. The course consisted of a series of practical hands-on activities and reflective discussions in international groups.

Ten facilitators, designated as *fa1*, *fa2* and so forth, from seven European countries with different levels of online facilitation experience were involved in the Trial, and 76 students from eight countries registered for the course. The students were under- and postgraduates majored in different fields of information and social sciences. They were divided into 10 different groups, designated as Group1, Group2 and so forth. Each group was supervised by a facilitator. The course lasted 14 weeks. All students and facilitators were required to create their own personal blogs to introduce themselves. Each group was required to develop an online course on the topic of their choice. For each week, there was a specific e-learning topic, and the students were required to read a list of related learning materials and to write their reflections on their individual as well as group learning activities in their blogs. Besides blogs, the students could also use other open source software to support different activities.

Feeding mechanism: iCamp aims to form a "distributed collaborative learning space" [5], in which the facilitators and students are allowed to easily share, exchange, search and browse blog data without moving back and forth among several blogs. A feed mechanism is a technical solution. It enables the creation of the mashed team feed to monitor blog postings and comments, i.e. making team member aware of each other's postings. This allows a user to reply to other users' postings not in their blogs but in his/her own blog. A user can also keep on his/her blog aggregated contents of all "subscribed" blogs. The iCamp technical team has developed a WordPress Feedback plugin to support the feed management, enabling the user to activate and deploy the feed mechanism easily [20]. The proposed feedback mechanism complements the existing feed standards, including RSS 1.0, RSS 2.0, or Atom. Note that a blog that a student is subscribed to is called a "channel", and the content it provides to that channel is called "feed" (for the technical details see [20]). Furthermore, the students were asked to categorise their blog messages with some predefined tags (e.g. groupXXreflection). The tagging scheme enables efficient search for specific messages in a blog. There two strategies – feeding and tagging - were solutions for tackling the challenge C1.

3 Data Analysis and Results

To tackle the challenge C2, we have developed a blog analysis scheme inspired by France Henri's [7] (Section 3.1). Furthermore, we have combined content analysis and social network analysis (SNA) techniques [19] to analyse and visualise the collaborative learning and interaction patterns derived from the blog messages (Section 3.2). The proposed analysis scheme has been deployed to evaluate the Trial, which is a very complex web-based collaborative learning context (Section 2).

3.1 Blog Analysis Scheme

We have much extended and adapted Henri's scheme [7] to the context of using blogs in an online cross-cultural collaborative learning environment. In Henri's scheme, the transcripts are analysed according to five dimensions, which are participative, interactive, social, cognitive and metacognitive. Her approach is grounded in a cognitive view of learning, focusing on the level of knowledge and skills evident in the learners' communications and has been applied widely for evaluating forum discussions in many online learning courses, e.g. [6, 14, 16]. Henri's approach, however, much focuses on forum-based communications, where everybody uses the same instrument provided. It also lacks detailed classification of electronic messages [14]. The cognitive and metacognitive dimensions defined in Henri's scheme are very hard to measure and the inter-rater reliability [17] tends to be very low.

In our Trial, we focus on evaluating the learning and interaction activities taken place in a *collection* of individual and group blogs. Our combined analysis scheme helps evaluate different dimensions of the collaborative learning activities using blogs. Basically, the blog posted messages (or entries) and comments are broken down into small units, which are separate meaningful ideas [17]. Each unit is coded and classified according to its type, content, its "sender" or "receiver" attribute, and its connectivity. Unique identifiers (IDs) are assigned to posting messages and their corresponding comments. Our analysis scheme explores different dimensions, each of which is briefly explained subsequently.

Learning process

The learning process consists of different parts, including Classified message units, Message categorisation, and Self-directed learning (SDL) competence development.

Classified message units: The message units are "typed". Such typing scheme would help reveal the features and patterns of the students' activities in their blogs. Four different types are defined, including TA (if the unit content is task-related), CO (if the unit content is about coordination, such as organising a group meeting), SO (social-related units) and TE (anything concerning technical issues). These types can be refined depending on the context and evaluation objectives.

Message categorisation: Individual blog messages, based on their meanings, were classified into the pre-defined sub-categories, which belong to one of the two so-called core categories, namely the Course Design and Groupwork. The former enables us to understand the students' perceptions about the organisational/pedagogical aspects of the course, whereas the latter helps understand the students' perceptions about different aspects of their groupwork undertaken during the course. Course Design subsumes the following sub-categories: "Expectations", "Assessment", "Social Exchange", "Difficulty", "Satisfaction", "Tool" and "Intention for Future Work". Groupwork subsumes "Difficulty", "Satisfaction", "Strategy" and "Facilitation".

Social network

Typically, a blog is written by a single user (the blogger) and is closely identified with that person [3]. A blog interaction may emerge when a user explicitly posts a comment to an original posted message or when a new message implies or refers to an idea raised by a previous message posted in the same or in another blog. The latter, however, is very difficult to locate. In our analysis, we address both interaction cases.

First, the interactions amongst the users, who post messages on the blogs, are constructed. Both *intra-group* and *inter-group* interactions are taken into account. The social networks constructed would help reveal (i) the learning community structure, (ii) the activeness and contributions of the participants to their own groups as well as to the whole community, (iii) the interactions and the relationships developed and maintained as the course progressed.

Second, the connectivity between the units are analysed and visualised. The questions investigated include "From each unit, were there any references to other units from the same or from other blogs?", "How was the complexity of the connected messages, e.g. the number of messages found in a chain of connected messages?" The message connectivity analysis allows us to evaluate the interaction process in online asynchronous discussions, e.g. how well and how often the students use blog for their collaborative learning activities.

3.2 Analysis Results

The duration of the course was 14 weeks. To facilitate the evaluation, the whole course was divided into three different phases according to the course schedule.

- Phase1: Week1 and Week2 in which one of the assigned tasks was to form groups
- Phase2: From Week3 to Week10. The major tasks assigned to students were to explore the tools, to investigate the appropriated learning resources as well as to design and develop an online course
- Phase3: From Week11 to Week14. The students were required to (peer-) evaluate other groups' courses as well as to improve their designed course based on the received feedbacks from other groups.

Descriptive statistics
In the period of 14 weeks, 749 messages and 766 comments were published. The idea of distributed collaborative space (Section 2) was not implemented effectively with only a relatively small number of facilitators and students having tried out this possibility. Eight facilitators activated the feedback plugin but only 6 of them really got feeds from their students in their own blogs. The others just added hyperlinks referencing to their students' blogs. Only two facilitators, (*fa1* and *fa5*) applied the predefined tagging scheme and four facilitators (*fa1*, *fa4*, *fa5* and *fa6*) published a message instructing their students how they should have tagged their blog messages. Hence, it was not surprising that very few students tagged their messages. While many of the students used their own meaningful tags, the others just did not bother with the tagging. Whilst 51 students activated the feedback plugin, only 28 of them got feeds from their facilitators and group members and they mostly viewed the new messages from the facilitators and their group members' blogs. The reply messages in their own blogs were rarely found. Only in Group1, in which the facilitator *fa1 strongly* encouraged her students to use the proposed feeding/tagging mechanism, the feed functions were more or less used as expected. It suggests that the other facilitators and students did not perceive blog as distributed collaborative space.

Learning process
Classified message units: The calculation of classified message units was based on the messages on individual blogs. As expected, the number of SO units in Phase1 was highest (corresponding to 49.3% of all posted units). Meanwhile, the number of TA units during Phase2 and Phase3, in which the students were required to work individually and in group, was the highest (54.5% and 59% of all the units, respectively). The number of units in Phase2 increased significantly (from 974 in Phase1 to 1705 units in Phase3) as this Phase was the longest one and the students were supposed to work hardest during this period. The number of units during Phase3 was lowest (674 units). This may be explained by the fact that in Phase3, only active students remained and they almost completed their tasks. The percentage of the posted TE (technical) units was low in all Phases.

Message categorisation: For the sub-category "Course expectation", the highest expectation was "Learning new things", which occupied 46% of the statement occurrence. "Meeting new people" was the second highest students' expectations (19%) as many students were excited to meet their peer students from other European countries. "Having fun" was mentioned 12% of the students' stated expectations. Concerning the sub-category "Satisfaction" under the core category Course Design, 29% of the statements were about a "good experience" the students had, another 29% was about the fact that the students learned something new and they achieved some benefits from the course. 20% of the statements implied that some students were satisfied with the way they completed the required tasks. For the subcategory "Difficulty" under the core category Groupwork, "passive members" was the biggest problem. 45% of the students' complaints about the groupwork difficulties were related to the passive members. In addition, the students expressed their difficulty in not receiving enough guidance from the facilitators. Another difficulty (27% of statements) was related to the differences in schedule (e.g. different time zones), working styles, etc.

SDL competence development: Results of the blog analysis also show that the active students gained much benefit from the course. In their blogs, many students expressed that they had improved their SDL competence, including:

- The ability to solve the problems on their own. Some even found the joy of working.
- The ability to read the provided learning materials, to search for related relevant resources and then to be able to analyse and understand what they have read to improve their own knowledge, to complete their assigned tasks.
- The ability to observe others' work, to learn from other people as well as the ability to collaborate with other group members to realise the group tasks.

Social network

Participant interactions

As expected, during Phase1 and Phase2 of the course, there were a very high number of *connected* participants. During Phase1, the facilitators and students exchanged several social and welcome messages/comments in their blogs. Some also discussed about their experiences from the previous courses in which they had participated. Phase2 could be considered as the working Phase in which the students were required to work individually as well as collaboratively with their facilitators and their peer students to design an online course. Hence, the number of connected participants correspondingly increased. Phase3 was the last Phase of the course and only active members kept on working till this Phase. In addition, the tasks during this Phase did not require many interactions from the participants. That is why the number of contacted participants reduced significantly in Phase3.

The whole course learning community is also investigated. We defined learning community in the context of our Trial as the combination of all the ten groups, including their facilitators. Fig. 1 shows the sociogram [19] (i.e. the social structure) of all the participants' interactions in Phase2 of the Trial.

In Fig. 1, the facilitators are represented by bigger (blue) nodes while the students are represented by smaller (red) ones. The members belonging to the same group are relatively positioned together (with Group1 on the top of Fig. 1). All groups had "isolated" nodes, which represent the students who did not have any interactions at all. The interactions were clearly visible in intra-group mode. One could see that the interactions were quite dense in Group1, 3, 5 and 8. On the contrary, there were very few intra-group interactions in Group4, 6, 7 and 10.

Several interactions were also found in the inter-group mode, many of which originated from *fa2*, or between the facilitators and students from the same country. Clearly, *fa2* played a central role in the whole community interactions. She interacted with many students of all the ten groups, though the student interactions in her own group (Group2) were not particularly strong. Another interesting case was *fa8*. This Finnish facilitator had very strong interactions with her local Finnish students. Interestingly, those Finnish students were mostly active students. They had very high technical skills and very good communications with each other.

Message connectivity

The message connectivity analysis and visualisation is important to see how the students used blog for their learning and collaboration. During Phase1, there were several *star-pattern* links found in almost all the blogs. It could be attributed to the fact that the facilitators and students posted their comments on the self-introduction messages in the blogs. There was a very few links found in inter-group mode. The cooperation/collaboration among students within a group usually started from Week3 onwards. We have noticed that the chosen group working approach depended heavily on the suggestion from the facilitators and/or from the active group members. Each group had a preferred communication tool for its groupwork. For example, most of the Group5 groupwork discussions took place on their Google group. Meanwhile, Group1 message interactions on the facilitator's blog and her active students' were very strong. Many links were found in those blogs.

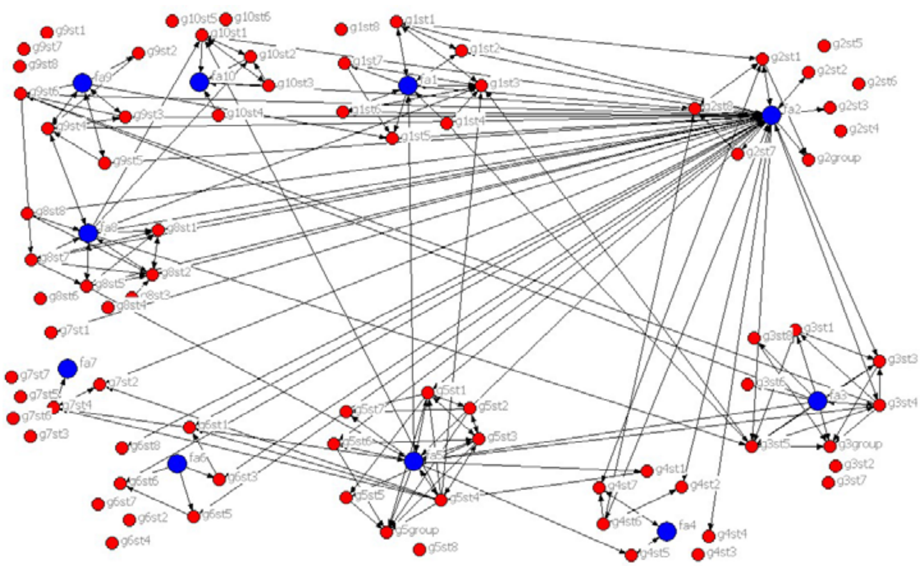

Fig. 1. The whole Trial learning community structure

4 Discussions

C1: Difficulty in browsing/searching blog archive

As a practical means to collect data from different blogs in one place, the feeding mechanism could greatly improve the efficiency of browsing/searching data posted in *different* blogs. However, it appeared that the facilitator's influence in organising his/her blog had a strong impact on the way their students used their blogs [5]. For example, in some groups where the facilitators were using the feedback plugin to monitor students' feeds, the students copied the same style for monitoring each other. Although the proposed feed management process made the feed usage much easier, it was still quite complicated for some students or even for some facilitators. Indeed, some feeding concepts were not intuitive, for example, the difference between replying to a blog message published by a peer in her blog and doing so in one's own blog. Indeed, the fact that only half of the students who had activated the feedback plugin exploited the feeding features (cf. Section 3.2) implies that some students might have had misconceptions about feedings. The facilitators also needed to use this mechanism effectively to demonstrate and encourage their students to use it. Furthermore, the mechanism was applicable only in the cases when students used the same blog provider, which was WordPress in our case.

A pre-defined tagging scheme would also help browsing/searching in group blogs easier. However, again, the facilitators should have strictly followed the tagging scheme to set the examples to their students. In addition, the usage of a pre-defined tagging scheme could be useful only if the students worked on a closely related topic, for instance, in a context of an online course. The tagging scheme would fail if it was applied to a set of heterogeneous blogs. Besides, the fact that some students created their own tags rather than applying the recommended ones implies that they might not have a clear understanding about the use of 'standardised' tags.

In summary, while some students found the feed mechanism useful, very few applied it as it was originally planned. To overcome this difficulty, some structured and direct guidance are necessary for both facilitators and students, especially in the preparation and beginning phases of the course. A solution to evaluate how the feeding/tagging mechanism affects the group collaborative learning activities as well as the group performance is to be explored more in the future work.

C2: Lack of a sound blog analysis scheme

The analysis results show that blog could be seen as a very rich evaluation source to study group interactions and collaborative learning activities in a web-based learning environment. Our proposed blog analysis scheme has proved useful in analysing a pretty large amount of blogs within a fairly short amount of time. It enables us to have a good understanding of the complex qualitative data of our Trial. As stated in [7], the organisation and retrieval of information is the basic function of message content analysis. Our proposed scheme defines the dimensions to be analysed and helps systematically explore such dimensions. The combination of qualitative, quantitative and SNA approaches allows one to dig into the richness of blog data and to construct the whole picture from different perspectives. The visualisation of blog interactions in both people and message unit levels help reveal the learning community structure as well as the blog usage and connectivity in a very intuitive way. The breaking down of blog messages into small units allow the evaluators to easily apply different coding and/or classification schemes if necessary. Furthermore, the dimensions mentioned are quite flexible, which allows the subdimensions and categories, or even some dimensions to be refined depending on the evaluation objectives and on the emerging results of the analysis. To sum up, the scheme can be easily applied to evaluate other blog-used scenarios and serve as an evaluation instrument for the blog-related studies.

However, we are well aware of the drawbacks of our approach. To classify and categorise the messages is rather subjective. So the coding, classifying and categorising processes should be performed in an iterative way with different coders or analysts. In addition, it seems straightforward to analyse and create the participant interactions; but it is very difficult to find out the message connectivity, i.e. to trace the references from one message unit to the others, which may be posted in the same or in a different blog. Furthermore, it is time-consuming to extract data from blogs, to analyse the data, to create the data matrices and then to generate the sociograms. A tool to automate this process would be a great improvement. The cognitive processes dimension in our scheme also remains as a future task as such dimension would help evaluate the information processing and cognitive deepness of the postings.

5 Concluding Remarks

As revealed by the analysis results, blog could serve as a powerful tool in web-based learning. It is especially useful to allow students to self-reflect their interaction and learning activities, to express their thoughts, ideas, and share/exchange them with their peers when working together. However, many factors could strongly influence the effectiveness and efficiency of blog usage in web-based learning. The students should be able to exploit the provided functionality. Some students may also think that blogs are only for personal diaries and they are not accustomed to sharing their thoughts publicly. Interestingly, there are apparently cultural differences in the student readiness for self-directed learning. Specifically, the Finnish students consistently outperformed their counterparts from the southern European countries in terms of activeness, leadership, level of motivation, autonomy, and critical thinking. Presumably the students from countries where autonomy is not encouraged may tend to be less self-directed. Such socio-cultural factors can have strong impact on the way the students collaboratively work using online tools, including blogs, especially when the intervention from the facilitators may be kept minimum. Much research effort is still required to exploit the potential of blogs as an educational technology. Although there is still much work to be done, our research work, especially the blog analysis scheme, could provide a useful evaluation framework to study blogs. The analysis scheme is theoretically sound and has proved useful in evaluating the complex cross-cultural collaborative learning course such as our Trial.

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Comparison of Learning Models to Build an Infrastructure for Performance Measurement of E-Learning Systems

Ercan Öztemel[1] and Elif Yavuz[2]

[1] Department of Industrial Engineering, Marmara University, Goztepe Campus, Istanbul, Turkey
[2] Adapazari Vocational School, Distance Education, Sakarya University, Esentepe Campus, Sakarya, Turkey

Abstract. In this paper, Models describing the learning process is compared in terms of six different criteria taking distance based education systems into account. The result of this study will be utilized in establishing learning performance assessment system in Adapazari Vocational School where main education is based on e-learning.

Keywords: Learning Process, E-learning, Learning Performance.

1 Introduction

The term learning and its importance grew up subsequently, necessitating the need for the learning models to be utilized in order to assure the best benefit of education curriculum and respective course content, especially in e-learning implementations. Since the focus of education and related technologies shifts from the instructor to the instructor's role as guide, coordinator, facilitator and coach of the learning process [1] the learning process, which assigned to learner's individual efforts, is more personalized in e-learning systems. Although Internet based education is accepted as the brand new education system, this success is still not yet expressed in confidence [2]. This enforces the educational institutions to measure effectiveness as well as efficiencies of their teaching process.

2 Learning Models

Under three approaches (Behaviourism, Cognitivism, Constructivism), there has been several learning models developed to make sure that "actual learning takes place". Due to the space limit, in this study 14 of those models which takes learning as process are compared. Their details are provided in Table 1.

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Table 1. Process-based Learning Models and Their Process Explanations

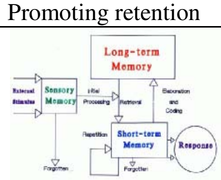
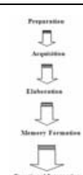
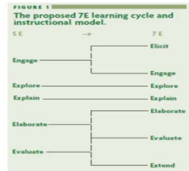
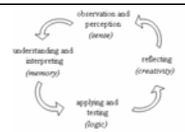
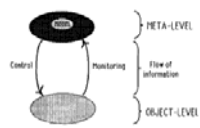
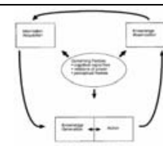
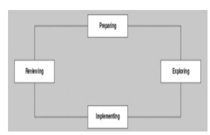
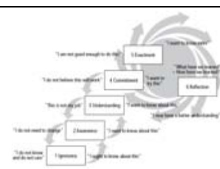
NO	NAME	PROCESS EXPLANATION	CONCEPTUAL MODEL
1	Social cognitive theory[3]	Attentional processes determine what people observe and what information they extract from what they notice. Retention involves an active process of transforming and restructuring the information conveyed. The behavioral production processes are translated into appropriate courses of action supported by motivational process.	Attentional Process ▼ Representational Process ▼ Production Process ▼ Motivational Process
2	Stages of cognitive development [4]	Equilibration; is ideal state and process that organize the balancing effort by assimilation and accommodation	Equilibration; Assimilation Accommodation
3	Discovery learning[5]	It involves students engages them in the synthesis, evaluation, extrapolation and analysis of the information at hand	Creation of know. Integration of know. Generalization of know.
4	Brain-based learning [6]	Three main topics associated with this model are orchestrated immersion, relaxed alertness and active processing.	Reflection Contemplation Creative Elaboration Combination Pro.
	Nine events of instruction	*Internal Mental Process* Stimuli activates receptors/Creates level of expectation/Retrieval and activation of short-term memory/Selective perception of content/Semantic encoding for storage long-term memory/Responds to questions to enhance encoding and verification/ Reinforcement and assessment of correct performance/Retrieval and reinforcement of content as final evaluation/Retrieval and generalization of learned skill to new situation [7], [8].	*9 Events of Instruction* Gaining attention-Activating motivation-Stimulating recall of learning-Presenting stimulus material-Providing learning guidance-Eliciting the performance-Providing feedback-Assessing the performance-Promoting retention
6	Stage model of information processing [9]	Stimuli processing Retaining information Elaboration and coding	
7	Five stages in the learning process[10]	Preparation Acquisition Elaboration Memory formation Functional integration	

Table 1. (*Continued*)

NO	NAME	PROCESS EXPLANATION	CONCEPTUAL MODEL
8	7E learning cycle [11]	Elicit Engage Explore Explain Elaborate Evaluate Extend	
9	Learning process [12]	Perception Understanding and interpreting Apply and testing Reflecting	
10	IMSTRA[13]	Evoking Exploring Synthesizing Explaining Practicing Extending	
11	Metacognition approach [14]	The model consists of two structures (meta-level and object-level) and two relations in terms of the direction of the flow of information between the two levels	
12	A cycle of learning [15]	Information acquisition Knowledge generation Action Knowledge Rountinization	
13	4 main process of learning how to learn [16]	Preparing Exploring Implementing Reviewing	
14	The stages of learning [17]	Learning requires a movement through the stages. These stages are ignorance, awareness, understanding, commitment, enactment and the reflection.	

3 Comparison of Models

6 criteria are used to compare the models. They are;

- *C1: Is there any performance indicator?*
- *C2: Does the model assess the change in the information level?*
- *C3: Are the respective sub-processes determined?*
- *C4: Are various ways of implementing these sub-processes determined?*
- *C5: Is there any performance indicator of these subprocesse?*
- *C6: Availability in Distance Education*

Figure 1 indicates the comparison of the models.

Criterions / Models	C1	C2	C3	C4	C5	C6
M1	✓	—	✓	✓	—	—
M2	✓	✓	✓	—	—	—
M3	—	✓	✓	✓	—	—
M4	—	—	✓	✓	—	—
M5	—	✓	✓	✓	—	—
M6	—	✓	✓	✓	—	—
M7	✓	—	✓	✓	—	—
M8	—	✓	✓	✓	—	—
M9	—	✓	✓	—	✓	—
M10	—	✓	✓	✓	—	—
M11	—	✓	✓	✓	—	—
M12	—	✓	✓	✓	—	—
M13	✓	—	✓	✓	✓	—
M14	—	✓	✓	✓	—	—

Fig. 1. Comparison Matrix

Learning does not occur suddenly, realized in the end of a concrete process that depends on learner's self effort, interpretation, and configuration; rather than the knowledge transferred from learning management systems. Evaluating the process based models given in the Table 1, 6 criteria are used. Determining these criteria basic characters of process based events and compatibility of model structures to distance education are considered. In these respect competencies of these models are weak and because of this weaknesses it is harder to realize these models in e-learning system.

4 Conclusions

Learning processes explained by models listed in Table 1 has formed a framework to analyze the subject conceptually; however there are some deficiencies about the performance indicators of these processes. In traditional education systems, some opportunities like observation of learning atmosphere, feedbacks from students; make easier to interpret the learning performance; however it becomes more difficult in distance education; especially in asynchronous systems. The unique way to measure the learning performance is interactive applications. In this study various learning models are compared in order to highlight their efficiency in e-learning environment.

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Online Platform Support for Sustained, Collaborative and Self-directed Engagement of Teachers in a Blended Professional Development Program

Thomas Osburg[1] and Albena Todorova[1,2]

[1] Intel Corp., CAG Europe, Dornacher Str. 1, 85622 Feldkirchen, Germany
thomas.osburg@intel.com
[2] University of Munich (LMU), Psychology of Excellence in Business and Education, Martiusstr. 4, 80802 Munich, Germany
albena.todorova@psy.lmu.de

Abstract. Professional development of teachers plays a significant role for the success of educational reforms and for student achievement. Programs for developing teachers' skills to integrate digital media in the classroom have received increased attention, due to the role of technology in today's world. Recent research and field experiences have identified elements which contribute to the effectiveness of such programs, among them opportunities for sustained, collaborative and self-directed learning. This paper explores how an online platform of a large scale blended program for professional development, *Intel® Teach - Advanced Online*, supports the implementation of such opportunities in practice and incorporates them in the structure of the program. The positive outcomes from the program as evidenced by its evaluation indicate that professional development based on the design principles identified as effective by recent research is a viable solution for addressing the limitations of traditional teacher training for technology integration.

Keywords: Teacher professional development, technology integration, self-directed learning, collaborative learning, sustained engagement.

1 Effective Professional Development: Factors and Components

In the age of the global knowledge society and the "skills revolution" [1], a focal point of development in the field of education has been the shift toward adequate, more learner-oriented learning environments and practices, which facilitate the development of information and communication skills, thinking and problem-solving skills, interpersonal and self-directional skills [2]. Governmental efforts to install new policies and to improve the educational infrastructure, however, are in vein if the teachers are not ready to adopt new pedagogical approaches and innovative practices and to apply them on a regular basis. Due to the role of technology in the knowledge economy and its innovative potential, the efforts in this regard have focused on training teachers how to integrate information and communication technology (ICT) and productive methodological approaches and practices in the classroom. In this context

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teacher professional development for technology integration has become a key issue in the discussion about successful educational change.

Professional development of teachers has been recently highlighted as one of the essential conditions for the sustainability of classroom innovation [3]. Furthermore, it is listed as one of the three key contributors for the achievement of the world's top-performing school systems as evidenced by OECD's Programme for International Student Assessment (PISA), along with the educational system capacity to attract quality teachers and to meet the academic needs of every child [4]. However, the outcomes from professional development programs vary greatly and are affected to a large degree by their design, the methodologies they are based on, their format and implementation. This paper explores how an online training platform in a blended program for professional development contributes to sustaining teachers' participation and involvement in the case of the *Intel® Teach - Advanced Online* program. The program was designed and implemented aiming to equip teachers with the necessary technical and methodological knowledge and skills to integrate technology in their classroom practice, and to provide them with a platform for individualized learning and for sharing knowledge, experiences and ideas about educational material.

1.1 Design Principles for Effective Professional Development

Research in the last two decades has yielded consistent evidence for the factors and components, which contribute to effective and sustainable implementation of teacher professional development in use of ICT. Empirical findings and practice show that effective professional development programs are sustained over time, have at their core professional learning teams for collaboration, involve teachers in solving authentic problems related to teaching and learning, deepen teachers' pedagogical skills and include opportunities for practice, research and reflection [5]. An important factor for the success of innovative uses of technology is the availability of mentors, who can help teachers adapt technology applications to their classroom needs [6].

The significance of these elements was highlighted already a decade ago by Hawley & Valli [7]. Eight advantageous design principles were identified in their meta-analysis of professional development literature. To be successful, professional development programs need to be part of a comprehensive change process and aimed at the improvement of student performance. In addition, teachers need to be involved in determining the focus of their learning, and should be provided with learning opportunities that are school-based, continuous and supported, information rich, and facilitating theoretical understanding and collaborative problem solving. Traditional expert-led and deficit-based professional development programs are seen as shallow, fragmented, frustrating and unauthentic. Later empirical and summative research showed that the successful integration of technology in the classroom is not so much determined by the level of digital literacy of teachers, as by the external support, access to up-to-date resources and participation in a community of teachers working with technology [8]. In summary, key components of effective professional development programs are opportunities to learn and practice innovative approaches over prolonged time, to work collaboratively on authentic tasks and to influence the choice of activities toward addressing the individual learning needs of teachers.

Despite recent efforts to transform professional development to meet these requirements, a large part of the centrally provided programs are delivered in single or short sequences of face-to-face sessions in the form of workshops, expert addresses followed by discussion and conference attendance [9]. Research indicates that the impact of these forms of professional development on the consequent use of ICT in classroom is negligible [7],[9]. Back at school once the face-to-face training is completed, teachers rarely have time to implement the new ideas in their lesson planning, apply them in practice, evaluate the effects, and adjust their strategies and approaches [10]. Unlike one-time delivery models for teacher professional development, it is suggested that sustained, collaborative, situated and reflective experiences are more likely to promote change in the teaching practice [7],[11].

Beside prolonged engagement in the professional development process, provision of opportunities for teachers to access and discuss quality teaching materials, to engage in collaborative problem solving, and to share the result of their work with other teachers can influence the adoption of new approaches. Collaboration and community have received increasing attention in professional development research [12]. To facilitate collaboration, communication and sharing, recent professional development efforts have been directed toward establishing virtual communities of practice. Socialization in such virtual communities provides teachers with opportunity to learn new skills and adopt new approaches [13]. This includes engaging teachers in identifying what they need to learn and focusing on collaborative problem solving in school-based contexts as part of a comprehensive process of change that is supported over time to drive teacher professional learning [7]. Predicting whether teachers would adopt an innovation or not depends also to a large degree on whether the teacher perceives it as relevant, meaningful and beneficial. “Self-direction” in professional development [14] relates to learning driven by teacher’s own initiative and addressing individual learning needs, which teachers have identified.

While the literature increasingly places value on sustained, collaborative and self-directional professional development, a face-to-face program integrating these elements is hardly implemental [7]. E-learning on the other hand provides a solution through its capacity to promote instruction that is more learner-centered, authentic, enabling learning independent of time and space, and adaptive to individual learning styles. The promise of technology-enhanced learning in professional development, has been associated at the same time with lack of social, emotional and professional support [15]. Combining online with face-to-face learning, regarded as blended, hybrid or mixed learning, offers more opportunities for building on the advantageous provisions of technology, while enhancing the social element of learning.

1.2 Blended Models for Professional Development

Although the blended learning approach is considered mostly as integrating e-Learning with face-to-face forms of instruction, the rationale behind the term is wider. It refers to the combination of different modes of delivery, methods and media, such as online, offline and face-to-face activities, computer and web-based training, paper and digital materials, individual and collaborative, guided and self-directed learning [16]. Main advantages of a blended learning system are the pedagogical richness, social interaction, personal agency, cost efficiency and ease of revision [17]. Blended learning approaches are considered to increase the level of active learning strategies, peer-to-peer learning strategies, and learner-centered strategies used [18]. Blended models for teacher professional development have been shown to address more effectively the learning needs of teachers [12],[19]. Face-to-face sessions added to online interaction are found to contribute for establishing long-term relationships and for developing an effective social network, which consequently stimulates greater participation, more open contributions and sharing of reflection on practices [12]. At the same time providing a web-based training platform enabling individualized learning, hosting resources, supporting communication, interaction and feedback, extends the traditional boundaries of face-to-face training.

2 Intel® Teach - Advanced Online

The teacher professional development program *Intel® Teach - Advanced Online* is one of the projects, designed and implemented within the Intel® Education Initiative - an endeavor of Intel Corp. towards advancing education as a major component of its Corporate Responsibility actions. Programs within the initiative comprise of teacher professional development projects, formal and informal technology-enhanced learning opportunities for students, science and technology competitions and talent search, and higher education projects.

One of the main components of the initiative is the *Intel® Teach Program* - a professional development program aimed at training classroom teachers to effectively integrate technology in instruction to enhance student learning, developed in collaboration with Ministries of Education and educational institutions. As a result of its implementation more than 6 million teachers in over 50 countries have been trained since 1999. The program is provided to elementary and secondary school teachers around the world and encompasses a portfolio of courses targeting different aspects of integrating technology in classroom teaching. The set of courses for classroom teachers vary to some degree in different countries but generally includes modules introducing classroom software productivity tools and student-centered approaches to learning; integrating technology into existing classroom curricula; using online tools to enhance students' higher order thinking skills; and advancing teachers' methodological skills. The focus of this paper - *Intel® Teach - Advanced Online* is one of the offerings within the program, developed and introduced in Germany and subsequently implemented in England, France, Ireland, Israel, Italy and Jordan.

2.1 Implementation, Design and Components

The program *Intel® Teach - Advanced Online* (*Intel Lehren – Aufbaukurs Online*) started with a pilot in 2003, following the successful implementation of the *Intel®Teach Basic Course (Intel Lehren - Grundkurs)* in Germany, which was combination of the basic course modules adapted for the local educational system. The concept for the advanced course was developed by the Academy for Teacher Professional Development and Personnel Management in Dillingen (ALP) - a state-owned Teacher Training Center belonging to the Ministry of Education in Bavaria, Germany [20].

The ALP assured the content of the program matched the curricula in all federal states and fostered the cooperation with various public education institutes.

The program is based on blended format of face-to-face meetings and individual and collaborative learning supported by an online platform, which enables self-paced on-the-job professional development. Participants in the program are guided and assisted in the training process by mentors – teachers who have expressed interest to become mentors and have received special training for the program to provide instruction and support. In Germany there are regional mentors for the federal states, who provide training and support to school mentors – teachers supporting the implementation of the program locally. This "train-the-trainer" approach enables a high degree of support, through the presence of mentors in the schools and communities of the participants in the program. The professional development process in *Intel® Teach - Advanced Online* follows a step approach (Fig. 1).

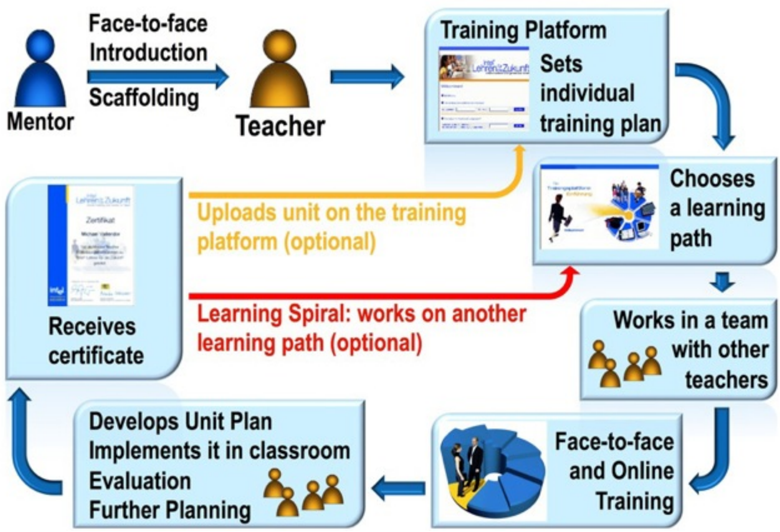

Fig. 1. *Intel® Teach - Advanced Online*: Training and certification process

After registration for the program teachers are introduced to the concept and content by a tutor in a face-to-face meeting. The next steps include using the online platform to study the available methodological information for integrating technology in a learner-centred classroom and example materials, and discussing in groups the requirements and objectives of the training. Teachers select a focus for their training from the possibilities available on the online platform, based on their personal professional needs. This pedagogical framework is called 'Learning Path' and within it teachers use a selected pedagogical approach or certain technological tool to develop a unit plan, implement it in their classroom practice, evaluate it and enhance it for further use. The intended distribution of time for completing a Learning path is 8 hours for introduction to the concepts, methods and technology, 12 hours for working on a Learning path collaboratively with other teachers, and 20 hours of individual learning using the available online resources and tools. The platform is customized for the countries where it is implemented, with several main areas to suit personalized needs at a particular time: areas for work with the learning path and areas with resources, collaborative tools, additional information and online support. The platform uses simple open source tools by collating and making available open source and free software tools to enable material creation. It is based on PHP technology, reflecting the desire from educational settings to adopt license-free solutions.

Self-Directed Approach. The program provides a context in which teachers can develop their technology skills and their understanding of the impact and implications of using technology within the classroom in a self-paced and self-directed learning process. Every learning path is either driven by its pedagogical approach or by the application of specific digital media, e.g. data handling and data analysis; using ICT to allow students to work collaboratively online. Learning paths can be chosen by subject, by concept (e.g. task-oriented, inquiry, hands-on, etc.), by various teaching methods and learning styles. The program curriculum consists of a minimum of one learning path, while the participant teachers are free to choose to work on more paths. Using the training platform is flexible and teachers have the choice to participate in the training from home or from school, depending on their preference and technology availability. Teachers also can access the platform after they have completed the program and use the available resources, ideas, unit plans and materials for self-directed learning.

Collaboration. In order to complete the chosen learning path, teachers work collaboratively using the online tools to plan and design curriculum and they can use for their classes the tools and resources provided on the platform. The online environment of the program and the embedded tools for collaboration enable teachers' joint work, solving problems and sharing knowledge, expertise, and materials. For instance, the German online platform includes a tool for sending messages to team members, a wiki with whiteboard for shared work and editing, chat for synchronous communication, a calendar for scheduling tasks and meetings of the team, a group forum and a platform-wide forum. At the same time, through contributing their unit plans and using unit plans of other participants, teachers also form a virtual community of practice based on the online platform.

Sustained Engagement. Although teachers receive training and support, the majority of their learning is done either in collaboration with other teachers, or individually and is extended over a period of time. When teachers develop an effective method that is working very well in their teaching and has shown good results with their students, they are encouraged to share it through fitting the method within the pedagogical template and then positing it on the platform for other teachers to benefit from. Teachers also evaluate their learning individually and collaboratively and plan for further enhancement and extension, which provides them at the same time with knowledge how to embed research and continuous evaluation in their day-to-day teaching.

2.2 Evaluation

The programs of Intel Teach are subject to systematic external evaluation for determining the direct effects of the training. The evaluation of the implementation of *Intel® Teach - Advanced Online* in Germany in the period from 2005 to 2008 was conducted by the Institute for Media and Educational Technology in the University of Augsburg [21]. The main aim of the evaluation was to provide information base for the continuous improvement of the program and the focus shifted from quality assurance in the earlier phases of implementation toward sustainability [22].

The evaluation included formative and summative components, implemented through quantitative and qualitative procedures. Data has been collected through an online, self-report end-of-training survey of teachers who complete the program (n=4633). Additional self-report surveys have been filled by mentors (n=152) online, and by teachers (n=418) and university students (n=67) at the educational fair Didacta 2006. For determining the conditions of implementation in the different federal states, online questionnaire including open questions have been filled by regional mentors of the program (n=14). In 2007 case studies of schools (n=16) in four federal states in Germany have been conducted through interviews and group discussions for examining the sustainability of the program and the factors for its successful implementation.

Overall, the evaluation findings as reported in detail elsewhere [21], [22] show that the program has a positive impact on teacher attitudes, competencies and practices of classroom technology integration. According to the most recent data reported [22], four-fifths of all participants declare that they have more ideas how to use digital media in their teaching. Nearly three-fourths of them significantly increased their confidence to use new media in the classroom and would recommend *Intel® Teach – Advanced Online* to other teachers. Regarding the impact on their practice, teachers report slight improvement of the quality of their teaching. This however is lower for teachers who are more experienced in using ICT in class, while teachers with less or no previous experience report a higher positive impact on their teaching quality. Regarding the indirect effect of the program on students, teachers report increased motivation in technology-enhanced classes, while the assessment of possible increase in students' skills is more conservative.

The usability of the online platform is mostly assessed as good, also when the general assessment of the program is lower. Specific aspects of the platform are rated high, such as the design, the quality of the content and the methodological approach of Learning paths. However, the online platform could not support professional development by itself. Although more than four-fifths of the participants found that the online training platform was important, they also considered significant that the platform is embedded in a professional development concept. Over two-thirds of the participants find the role of the mentors in the program important and are satisfied with the mentor support they received.

One interesting finding is the strong impact of effective collaboration on individual learning gains. When collaborative work with other teachers was successful, teachers reported higher competence gains compared to the cases in which the collaboration did not work well (Fig. 2). The collaborative learning amongst groups of teachers is

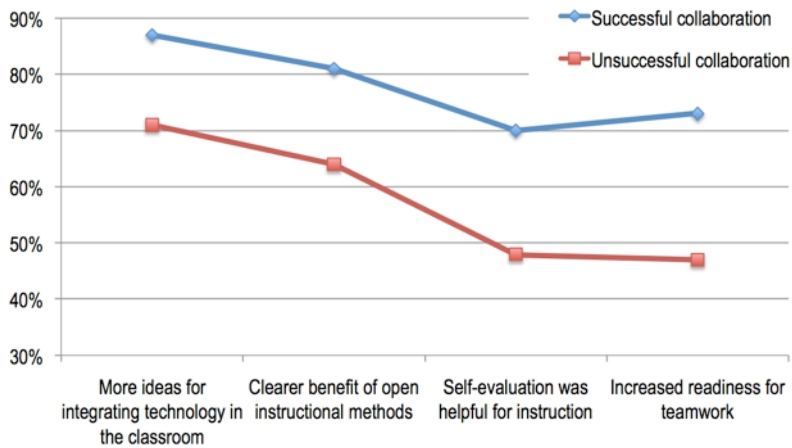

Fig. 2. Significance of effective collaboration for learning gains of teachers

sometimes a fundamental change to previous teacher behaviour. However, in *the Intel® Teach - Advanced Online* the need to collaborate was easily accepted by the teachers and contributed to their learning in the program. Particularly high satisfaction with the collaborative activities was expressed by teachers who worked in a team with colleagues from the same discipline.

The evaluation findings showed that teachers not simply completed the program, they also used intensively the opportunities for self-directed and sustained professional development, as well as for collaboration with other teachers. For completing one learning path they spent on the average 16 hours in individual study, 12 hours in learning with the team, and almost 10 hours implementing the methods in the classroom. At the same time the duration of teachers' participation in the program was on average almost seven months, showing a prolonged engagement with the available resources. The findings show that teachers were more successful with the program when they spent more hours working on it. Furthermore, after receiving their certificates nine out of ten participants continued to use the online platform and more than two-thirds continued to work with their teams on other learning paths. Despite the limited weight of the evaluation findings as evidence for the effectiveness of sustained collaborative and self-directed learning as single elements, the experience from the implementation of *Intel® Teach – Advanced Online* offers an example of their application in practice and allows us to discuss some further implications.

3 Conclusion and Implications

The positive outcomes from the implementation of *Intel® Teach – Advanced Online* indicate that integrating self-directed, collaborative and sustained learning opportunities in a blended program for teacher professional development is a viable solution for addressing the limitations of traditional teacher training for technology use. Working collaboratively with other teachers on a project to develop a unit plan for technology-enhanced class can be successfully supported by an online platform. Incorporating opportunities for individualized, self-directed and self-paced learning, embedding tools for facilitating collaboration, and providing rich resources usable in teachers' practice contributes to the sustained engagement of teachers in the professional development process.

Additionally, the format and structure of the program make teachers' experiences personally relevant. The flexible e-Learning opportunities allowing teachers to choose to do the training from home or in school also enables a closer link of the professional development to teachers' work and direct transfer of the new knowledge and ideas to the teaching practice. The authentic experience of designing, developing, implementing in practice and evaluating a unit plan, is clearly advantageous for developing skills for integrating digital media in the classroom. The opportunity to collaborate with other teachers, share experiences and practices, and learn from each other's real-life classroom solutions are highly relevant and promote the adoption of new approaches and ideas. Teachers are generally used to prepare classes on their own, however the results from the evaluation point at collaboration between teachers as a major positive influence for their experiences.

The implementation and outcomes of the *Intel® Teach - Advanced Online* program raises the question of whether training for technology inclusion in the classroom should be based on best practices or future practices. Technologies and their applications are developing so fast that equipping teachers with the necessary competencies and skills might seem a futile quest. Focusing on basic computer skills and provision of ready for implementation materials in this respect have a low potential for producing sustainable effect. In contrast, teachers' experiences with analyzing their own learning gaps and developing and testing solutions empower them to take the initiative in identifying and acting on their own individual needs and give them an advantage in meeting the challenges of the future.

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Asynchronous Distance Education Forum - Brainstorming vs. Snowballing: A Case Study for Teaching in Programming Didactics

Kiriakos Patriarcheas and Michalis Xenos

Hellenic Open University, School of Sciences & Technology, Computer Science,
23 Saxtouri Street, GR 26222, Patras, Greece
{k.patriac,xenos}@eap.gr

Abstract. Asynchronous discussion fora all the more become part of the educational process of distance education. The goal of this research is the study of the educational techniques of Brainstorming and Snowballing to their utilisation in the frame of a distance education forum, both as far as participation and creation of learning environment and also educational effectiveness are concerned. This research refers to computer teachers' training on didactics of programming within the framework of educational micro-worlds. As it is deduced from the data analysis and the study of the messages higher participation and improvement of critical thinking are noted when Brainstorming technique is used, while fairly less time is spent and less off-topic interventions are made when Snowballing technique is used. Meanwhile, Brainstorming is found to be more advantageous than Snowballing concerning the effectiveness both in primary level (trained teachers) and in secondary level of adaptation and knowledge impartment to the students (results of their students).

Keywords: Asynchronous discussion fora, Distance education, Brainstorming, Adult education, Modelling, Snowballing.

1 Introduction

Distance education offers a "learner-centred" standard allowing to students to learn in their own pace and explore the educational material to the extent they wish [1]. Given that the student often feels isolated [2], [3], the quality of offered education is based, among others, on the quality of the communication between the student and the teacher [4]. Despite the fact that the growth of the internet was exponential in the last years, still many communities do not benefit from web technology for their learning issues due to improper tools and constricted communication processes [5].

An important communication tool is the asynchronous discussion electronic forum, or e-forum, hereinafter called forum (plural fora). This study focuses both on the participation parameter and the creation of a learning environment as well as the educational effectiveness of Brainstorming and Snowballing educational techniques in their utilisation at a distance education forum using the open source framework

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Moodle (version 1.8.3), within the frame of training high school computer teachers on didactics of programming in the educational micro-worlds environment. It is worthy to note here that for this study it was utilized the previous practical and research experience within the framework of Hellenic Open University (HOU) and concerns, among others, previous projects related to HOU students attitude [6], [7], as well as to the fora modelling as a methodology of messages' interpretation [8].

The structure of this article is the following: Section 2, where it is presented the respective theoretical framework and a brief literature review; section 3 where it is presented the methodological framework of the study and comprises sample, method, activities, process and modelling used; section 4, where there is the data analysis; section 5, where it takes place the respective discussion and section 6, where there are presented the results combined with the conclusions of relative studies as well as the future goals.

2 Theoretical Framework

There are numerous studies on educational techniques used in fora, some of which concern Brainstorming and others Snowballing. Indicatively, in relation to Brainstorming technique some [9] adopt the term Electronic brainstorming (EBS) referring that “it has been proposed as a superior approach to both nominal brainstorming (working alone) and face-to-face brainstorming (verbal)”, while others [10] adopt the term “IT-Supported Organisational brainstorming”. There are studies which examine the productivity [11] or the creativity [12] in a web-based context of asynchronous electronic brainstorming groups, or try to particularise in subcategories of the technique, namely Camacho & Paulus [13], refer to solitary brainstorming while others [14] to “very large groups” of brainstorming. Other studies [15] examine the potential of cognitive stimulation in brainstorming, while others [16], [17] which explore the unblocking brainstorming and some others [18] which attributed the superiority of electronic brainstorming to a number of factors, including the technology's ability to reduce production blocking.

In relation to Snowballing technique Thomas & Carswell [19] use it in their effort to assess the role of collaborative learning in a distributed education environment within the framework of a relative research of Open University of London, highlighting that it offers essential support for students studying at a distance, while others [20] use it when evaluating the role of the evaluation process in sustaining and developing quality distance education programs in collegiate aviation. Kember & Gow [21] also evaluate it when studying the action research as a form of staff development in higher education, in attempting to improve their own teaching through cycles of planning, acting, observing and reflecting.

From the relative literature survey, it is concluded a gap as for the methodological approach which will be based on modelling with the use of typical language and which will examine the two techniques in combination both in primary level (of trained people) and to secondary level of adaptation and knowledge impartment (results of their students at a chosen process). This research wishes to contribute to cover this gap. This research refers to adults training (computer teachers) on didactics of programming within the frame of educational micro-worlds (emphasizing on

StarLogo language). At this point and before moving further down, it is advisable to slightly refer to micro-worlds environment. The term “micro-world" is not a new one; it has been used many time in the past to describe usually small-scale systems (for instance tiny ecosystems) which function almost unaffected by their immediate environment. Papert [22], was among the first using this term so as to describe an educational environment in his description of Logo language. Many micro-worlds (e.g. spreadsheet) are not manufactured for educational purposes (as Logo or Cabri are); they are often used, though, within this framework because they are appropriate for educational use. Consequently, programming micro-worlds may be used within the framework of a course introductory to programming [23].

3 Methodological Framework

3.1 Sample

This research was conducted during May to October 2008 in 4 Training Centres of Piraeus, Greece. The sample was constituted by 64 High School Computer Teachers and 1253 students of theirs, at the area of Prefecture of Piraeus within the framework of a training program of Ministry of National Education under the unity entitled “Didactics of Informatics”. The training was conducted in order to integrate within the Informatics lesson of 3rd class of High School the micro-worlds environment for introduction to programming, experimentally for this year (2008-9) and compulsory from year 2009-10. All trained people were of the same level of knowledge and did have (until the program's beginning) no knowledge of the micro-worlds software and StarLogo language. There were evaluated the discussion thread on forum (in all 1110 messages), the results of the trained professors in 5 modules of the program (360 marks), as well as the students’ results in a chosen activity after the experimental teaching of 9 hours.

3.2 Method

Trained teachers were grouped in 4 groups of 16 people which were endeavoured to be absolutely uniform as far as the members’ education profile was concerned (level of studies, age, experience, sex etc.) Supporting material with the concepts to be presented, as well as a manual with the languages’ commands were available via internet before the program’s beginning; in addition, by the program’s beginning, there were distributed from tutors to the trained teachers 8 subjects for the creation of lesson plans, which should be developed and applied by each one in their classroom within a duration of 9 hours. One hour was used for questions’ resolution in each classroom. Moreover, it was agreed with the 64 teachers that after this procedure there would be given a chosen activity to the students of the respective schools as a test (in all 1253 students, approximately 20 per class). The participating schools are city neighbourhoods of Piraeus Prefecture and are of the same socio-cultural level.

Training was base upon Moodle forum, while there also took place seven (7) 3-hour advisory meetings in each group. Furthermore, after the end of each of the 5 modules of the program, a self-evaluation test was completed by the trained teachers. The aforementioned educational procedure is mainly applied by HOU in Greece.

3.3 Activities

The lesson plans distributed to the trained to be developed, should comprise: a) title for the hourly module b) the goals of the course (as for knowledge, skills, attitudes), c) sub-units, (parts into which teaching shall be divided) and time used for each one, d) educational techniques and teaching aids to be used for each sub-unit and e) justification of the above choices. The lesson plans concerned activities for the simulations' development due to the fact that this language uses graphic representations, animation and interaction between characters.

Indicatively, it is presented the activity agreed to be given by trained teachers to their students as a test (after the 9 hours teaching) and which concerned the creation of a simulation for “virus transmission" (fig.1) on the following assumptions: a) There is a focus of infection, consequently there is an area (within Starlogo environment) which represents the focus of infection (e.g. a chip) b) they are necessary many items which will play the role of beings to be infected (e.g. Starlogo's ingots) c) a rule is necessary by which an infection is transmitted d) It is taken that all ingots are uninfected in the beginning. For this reason all ingots should be painted white e) as focus of infection is considered a chip on the screen. So as to distinguish its position it shall be painted red and thus each ingot which will be infected shall turn red and f) if, while randomly walking, an ingot passes over a focus of infection then it gets infected.

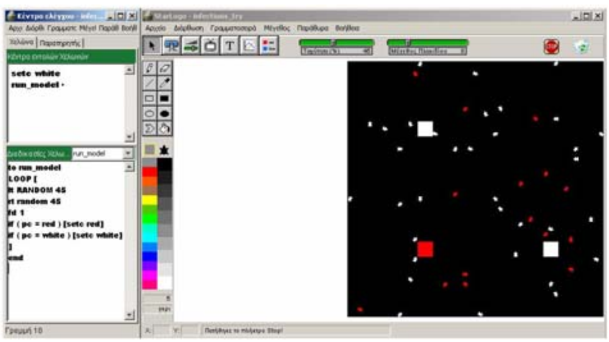

Fig. 1. The Starlogo micro-worlds environment (commands' menu is in Greek)

3.4 Procedure

During the asynchronous discussion on the forum it was decided to use the educational techniques Brainstorming and Snowballing. More specifically in two groups (1st and 2nd) Brainstorming technique was used while in the other two (3rd and 4th) Snowballing technique was used.

In the case of Brainstorming the procedure intended to the exposure of numerous sides of the issue of didactics of programming through the micro-worlds to the students of 3rd class of High School, the knowledge enrichment of the trained and finally the consolidation or change of their opinions. In particular, the procedure which took place exclusively through Moodle forum and was repeated in each course of the program was the following: a) They participated all in the same thread and each one was stimulated to express their own ideas in a spontaneous way even if their ideas seemed unrealistic at a first level without being necessary (at this phase) to explain them and without criticism on any of them b) The tutor codified all ideas and presented them in a uniform form c) Each trained was asked to explain or even modify (if they wanted) their initial placement d) At the end of the procedure, it was stimulated to compose the opinions and to reach conclusions as for the compilation of lesson plans, the educational techniques to be used by each one in their school, the supporting material to be distributed to the students etc.

Snowballing technique was chosen for the exchange of views in order to advance and expand the teachers' consideration as far as the didactics of programming concepts through micro-worlds to students of the 3rd class of High School is concerned. In particular, the procedure which took place exclusively through Moodle forum and was repeated in each course of the program was the following: a) The trained people had the opportunity to comment the issues of the concepts' teaching approach in micro-worlds environment they faced b) Then each trained person compared their comments to another (by creating threads of 2 people) c) The same procedure was repeated in groups of four and d) At the end of the procedure all the trained of the group participated (16) presenting all the views in a plenary session and they tried to compose their views and to reach conclusions, as they did in Brainstorming technique. At this point it is advisable to present the modelling used.

3.5 Modelling

Based on observations at HOU fora the following became evident: a) There are two categories of communication actors: Tutors and Students. For brevity, tutors will be symbolised with a *T* and students with an *S* b) As regards message types, these are distinguished into questions and answers. Hereinafter, symbolised with *q* and *a* respectively c) As to their content, messages are distinguished into those relating to (the respective symbols are given in brackets): i) study of educational material (*M*), ii) questions/answers for exercises – assignments (*X),* iii) presentation of sample assignments by tutors (*P*), iv) instructions (*I*), v) assignment comments, corrections (*C*), vi) student comments on assignments (*D*), vii) sending – receiving assignments (*J*), viii) sending - receiving grade marks (*G*), ix) notification of advisory meeting (*V*) and x) pointless message (*L*).

Finally, the order in which above symbols will be written is: a) message carrier b) message type and c) the content of the category to which the message belongs.

A message concerning a student's question for an assignment is represented as: *SqX* (where *S* for student, *q* for question and *X* for the fact that this message is about an assignment). An indicative example is presented that contains a series of messages represented by the sequence *SqVMTaVMSqMXSaXM,* which, according to the above, represent a discussion thread as follows: in the beginning is a message whose sender is student *S* who is asking a question *q* referring to forthcoming advisory meeting *V* and also concerning the study of educational material *M*. This message is replied to by tutor *T* who is answering *a* referring to forthcoming advisory meeting *V* and also about the study of educational material *M*. This message is replied to by student *S* who is asking a question *q* concerning the study of educational material *M* and also about the forthcoming assignment *X*. This message is replied to by other student *S* who is answering *a* about the forthcoming assignment *X* and also about the study of educational material *M*. As it is obvious this modelling uses a typical Language. Additionally, it should be noted that for this Language it was used a syntax check algorithm, as well as a respective tool to automate this procedure by inserting threads from discussion fora and exporting the respective strings.

4 Data Analysis

In groups 1 and 2, where Brainstorming technique was emphasized we received 613 messages; 51 were from the tutor and 567 from the trained people. Given that, according to the above modelling, in each message more than one categories of content may be included (e.g. in the same message may be a question on study of educational material and on a project too), there were confirmed 1239 such questions. Respectively, in groups 3 and 4 where Snowballing technique was emphasized, we received 497 messages; 36 from the tutor and 461 from the trained people while, as far as content categories are concerned we had in all 749 appearances. The above information is presented in Table 1.

Table 1. Appearances number (AN) per message content category (CC) based on modelling

groups 1 and 2 (Brainstorming)											
CC	M	X	P	I	C	D	J	G	V	L	Total
AN	290	347	21	26	121	169	160	16	14	75	1239
percentage	23.41	28.01	1.69	2.10	9.77	13.64	12.91	1.29	1.13	6.05	100
groups 3 and 4 (Snowballing)											
AN	128	158	21	19	88	113	160	16	14	32	749
percentage	17.09	21.09	2.80	2.54	11.75	15.09	21.36	2.14	1.87	4.27	100

If we take into account only the trained people interventions, then we have 839 appearances for Brainstorming groups. This comes if we deduce the tutor's interventions and the said "service type" of interventions, i.e. the categories presentation of sample assignments by tutors (*P*), assignment comments, corrections (*C*), sending – receiving assignments (*J*), sending - receiving grade marks (*G*), notification of advisory meeting (*V*) which function as separate variables according to the initial plan, as well as the tutor's interventions appearing on the rest content categories. The respective number of appearances for Snowballing groups are 433. The above information is presented in Table 2.

Table 2. Appearances number (AN) per message content category (CC) without the tutor's interventions

groups 1 and 2 (Brainstorming)					
CC	M	X	D	L	Total
AN	269	326	169	75	839
percentage	32.06	38.86	20.14	8.94	100
groups 3 and 4 (Snowballing)					
AN	107	138	113	32	433
percentage	27.44	35.58	28.97	8.21	100

As far as the trained people's performance in each test of self-evaluation at the end of each module is concerned, the collective data for groups 1 and 2 (Brainstorming) and 3 and 4 (Snowballing) are presented respectively on Table 3. For the estimation of the central tendency of the results, the three Pythagorean means and the average of interquartile range were taken into account. The three classical Pythagorean means are the arithmetic mean, the geometric mean, and the harmonic mean. As for the average of interquartile range (I.R.) there were taken into account the means i.e. (50%) without counting the highest and the lowest quarters of values (25% and 25% respectively). The means' choice (not only the average) was done so as not to "be affected" by exceptionally high or low values. On Table 4, there are presented the statistics measures of central tendency concerning the trained teachers' and their students' performance at the tests (of the chosen activity) after the 9-hour teaching.

Table 3. Marks of the trained teachers per module (excellent =100)

groups 1 and 2 (Brainstorming)							groups 3 and 4 (Snowballing)						
Marks	**Course**	**1**	**2**	**3**	**4**	**5**	**Marks**	**Course**	**1**	**2**	**3**	**4**	**5**
	61-70	5	0	0	0	0		61-70	12	2	3	0	3
	71-80	11	7	5	0	0		71-80	12	10	10	5	5
	81-90	10	15	17	18	4		81-90	8	16	17	16	14
	91-100	6	10	10	14	28		91-100	0	4	2	11	10

Table 4. Statistics measures of central tendency concerning the trained teachers' and their students' performance (excellent=20) at the chosen activity

	teachers				their students			
mean	***Geom.***	***Harm.***	***Aver.***	***I.R.***	***Geom.***	***Harm.***	***Aver.***	***I.R.***
group1	87.65	87.30	87.99	89.08	15.17	15.16	15.18	15.30
group2	87.87	87.59	88.14	89.05	15.20	15.19	15.21	15.28
Brainstorming	87.76	87.44	88.07	89.14	15.18	15.17	15.20	15.29
group 3	81.86	81.34	82.36	83.10	14.59	14.58	14.60	14.59
group 4	81.17	80.70	81.63	82.60	14.53	14.53	14.54	14.41
Snowballing	81.51	81.02	82.00	82.83	14.56	14.55	14.57	14.53

5 Discussion

As it is deduced from the data analysis, in groups where Brainstorming was used, higher participation at forum is noted, compared to Snowballing both as for messages (613 against 497) and as for range of content categories (1239 against 749). Furthermore, if from this number the content categories P, J, G, V are deducted, as well as the tutor's interventions, which in our case constitute separate variable, then the discrepancy (respectively) increases even more (839 against 433). Moreover, even if we deduct the needless messages (L), then the discrepancy of participation (in educationally substantial categories) is 764 against 390.

In Brainstorming case in relation to Snowballing, there is noted enforcement of the creativity and the participants' experiences; this finding arises from practical experience and messages' texts analysis and also from the fact that we have 269 against 107 and 326 against 138 for the categories: study of educational material (M) and questions/answers for exercises assignments (X) respectively. In addition, it is noted improvement of critical thinking (category: student comments on assignments (D): 169 against 113).

On the other hand, at Brainstorming technique it comes the phenomenon of more needless messages, i.e. off topic interventions (75 against 32). Despite the fact that it can be quantitatively proven, meanwhile the observation and study of messages' contents offers (in a quite small extent) a show of imagination by a smaller percentage of participants in Brainstorming technique, in contradiction to Snowballing technique. This may be explained given the fact the Snowballing technique is more "disciplined".

As it can also be seen in Tables 1 and 2, a slightly uniform distribution to both techniques is noted, as far as where the attention is during the forum discussions, both throughout all the messages and also to those remaining if we deduct the messages functioning as separate variables. It becomes thus obvious that (*X)* category: questions/answers for exercises – assignments comes first (347 and 326 against 158 and 138) and it follows the (*M*) category: study of educational material (290 and 269 against 128 and 107).

As far as the effectiveness of the two techniques is concerned, it is obvious the advantage of Brainstorming against Snowballing, both in primary level concerning performance in self-evaluation tests of the trained people (average 88.06 against 81.99) and in secondary level concerning the students' performance at the procedure chosen to be the test (15.20 against 14.57) after the application of lesson plans, which were applied by the same teachers. This given is reinforced by the appearance of similar results among the groups (87.99 against 88.14 in groups emphasizing on Brainstorming against 82.33 and 81.63 of Snowballing) and also (15.18 and 15.21 against 14.60 and 14.54 average student performance, respectively). The above assumptions are certified not only in relation to arithmetic means and geometrical, harmonic and arithmetic means of the interquartile range but also at trained teachers performance (in self-evaluation tests) as well as the respective students of theirs in the chosen activity.

6 Conclusions and Future Goals

As it is deduced both from data analysis and also from the study of the text messages in Moodle forum, the groups where Brainstorming technique was emphasized show higher participation at the forum. Furthermore, it is noted a bigger enforcement of the participants' critical thinking. On the other hand, at Snowballing technique is noted that quite less time is spent and there are not off topic interventions in relation to Brainstorming. Meanwhile, Brainstorming is more advantageous than Snowballing concerning the effectiveness.

As for the high participation rate of Brainstorming, despite at first it may seem presumable, however it is not always like that, given that "a poorly crafted brainstorming input creates a cognitive load that consumes attention resources and may stifle the brainstorming process" [14], while according to Michinov and Primois [12] participation is encouraged "only when participants have access to a shared table facilitating the comparison among group members". As for the ascertainment of educational participation of Brainstorming in this study, it is at first in contrast to a respective study [9] where it is highlighted that “the prevailing popularity of group brainstorming (verbal or electronic) in organizations may be explained by the perceived productivity” and that “these perceptions, which are at odds with reality, create the illusion of productivity”; but Camacho & Paulus [13], who, despite ascertaining the same, however explain that “part of the productivity loss observed in interactive brainstorming groups may be due to the inhibited performance of individuals who are uncomfortable with group interaction”; Michinov and Primois [12] are of similar opinion. This conclusion is also reached by a respective study [15] where it is noted that “the attentional set of the participant and the content of the exposure manipulation (number of ideas, presence of irrelevant information) affected its effectiveness”. The conclusions of this study may be thus explained (as far as brainstorming effectiveness is concerned) and agree with relative study [18] that conclude that “electronic brainstorming groups were found to be significantly more productive” and likewise Hymes & Olson [16], who support their opinion about unblocking brainstorming through the use of a simple group editor, as well as Stenmark [10] who in one of his «three general pieces of managerial advice” eagerly urges: to «allow redundancy”. Similar consideration there is about snowballing by Thomas & Carswell [19], who for instance remark that “it is helpful if each sub-group to be given a different, but related task” which in other cases, e.g.[20] cannot occur due to the nature of the educational object. Consequently, when studying the results of this study, we had in mind that the educational practices are regarded as social practices to be changed through collaborative action [21].

Among others, as future research actions there are predicted long-term comparative studies of Brainstorming and Snowballing techniques in relation to HOU topics with studies focusing on other programming environments. Additionally, it will be more emphasized the central question, what reinforces the participation at fora and how this contributes to the educational process effectiveness by investigating side questions, such as how much it affects the person who starts the thread (teacher or student), how it starts, the period when the thread starts, how important is the time of response in threads, the groups’ size etc. in combination with these two techniques.

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Addressing Learning Style Criticism: The Unified Learning Style Model Revisited

Elvira Popescu

University of Craiova, Software Engineering Department
A. I. Cuza 13, 200585 Craiova, Romania
popescu_elvira@software.ucv.ro

Abstract. Learning style is one of the individual differences that play an important but controversial role in the learning process. This paper aims at providing a critical analysis regarding learning styles and their use in technology enhanced learning. The identified criticism issues are addressed by reappraising the so called Unified Learning Style Model (ULSM). A detailed description of the ULSM components is provided, together with their rationale. The practical applicability of the model in adaptive web-based educational systems and its advantages versus traditional learning style models are also outlined.

1 Introduction

Learning style is a controversial issue both in educational psychology and in the field of adaptive educational systems.

The main reason, which is common to all educational research, is the innate complexity of the learning process [6]. The factors that affect it are numerous and interconnected: overall IQ, motivation, socio-economic background, time, effort, health, reinforcement, class environment etc. Furthermore, because of the complex nature of learning, it is difficult to isolate the effect of any given factor; due to the numerous uncontrollable variables, the results obtained in an experiment cannot be safely attributed to any particular cause.

There are also some reasons which are specific to the learning style domain. This paper aims at discussing these controversial aspects regarding learning styles, both in traditional and in technology enhanced learning settings. Furthermore, we try to address some of the identified criticism issues by proposing a Unified Learning Style Model (ULSM), which synthesizes characteristics from the main models in the literature, providing an integrative taxonomy. An initial proposal of the ULSM has been introduced in [32]. Since then, the model underwent a refining and validation process and was successfully used into practice: an e-learning platform called WELSA (**W**eb-based **E**ducational system with **L**earning **S**tyle **A**daptation) was built on it [33], [34], [35]. In the present paper we present the revised version of ULSM, together with a detailed description of each of its components and the traditional models they were inspired from. We argue that ULSM is the best choice for a learning style based adaptive educational system and we outline its advantages.

The rest of the paper is structured as follows: we start with some theoretical aspects, including definitions of learning styles and their implications for pedagogy. Next, in

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section 3, we discuss the most frequently raised criticisms regarding learning styles. As a response to these challenges, in section 4 we introduce our Unified Learning Style Model, justifying its use. The last section contains conclusions and future research directions.

2 Learning Style Background

Learning style designates everything that is characteristic to an individual when she/he is learning, i.e. a specific manner of approaching a learning task, the learning strategies activated in order to fulfill the task. A widely accepted definition is given by Keefe [25]; according to it, learning style represents "the composite of characteristic cognitive, affective, and psychological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment".

There has been a great interest in the field over the past 30 years, which led to the proliferation of proposed approaches. Coffield et al. [10] identified 71 models of learning styles, among which 13 were categorized as major models, according to their theoretical importance, their widespread use and their influence on other learning style models. These models differ in the learning theories they are based on, the number and the description of the dimensions they include.

Each of the learning style models offers a set of principles and recommendations for the instructional strategies that should be used with the students pertaining to each learning style category. Most psychologists recommend that the teaching style of the instructor should correspond to the learning style of the student (the "matching hypothesis"). Felder mentions that mismatching can have serious consequences: students may feel "as though they are being addressed in an unfamiliar foreign language. They tend to get lower grades than students whose learning styles are better matched to the instructor's teaching style and are less likely to develop an interest in the course material" [14]. Dunn and Griggs also suggest that teachers adapt the instruction and environmental conditions by allowing learners to work with their strong preferences and to avoid, as far as possible, activities for which learners report having very low preferences [11].

Some other psychologists support an opposite point of view: using a variety of teaching styles and providing mismatching materials could help avoid boredom and at the same time prepare students develop new learning strategies and improve their weaker learning styles [2], [20].

Another important role of learning styles would be to increase self-awareness of the strengths and weaknesses of the students during the learning process. According to [38], the potential of such awareness lies in "enabling individuals to see and to question their long-held habitual behaviors"; individuals can be taught to monitor their selection and use of various learning styles and strategies. Moreover, as [2] suggests, an understanding of the various elements which produce different states of motivation in different contexts can "allow people to come more in control" of their motivation and hence of their learning. Students can become more effective in their learning if they are made aware of the important qualities which they and other learners possess [10].

Despite the importance given by specialists in educational psychology starting 3 decades ago, learning styles have only been introduced relatively recently in technology enhanced learning. During the last years however, they began to receive special attention, and several learning style based adaptive educational systems (LSAES) started to appear. Most of these systems take a single learning style model into account, such as:

- Felder-Silverman (FSLSM) [13] → used in [3], [7], [9], [19], [39]
- VARK [15] → used in [17], [44]
- Honey and Mumford [24] → used in [30]
- Witkin's field dependence/field independence [45] → used in [42].

3 Learning Style Criticism

3.1 Studies in Traditional Learning Settings

The report published by Coffield et al. [10] is a critical review of the main learning style models that have been introduced in the literature. However it should be noted that the main criticism is addressed at the measuring instruments of the learning style models (which suffer from psychometric flaws), and not at the models themselves. The 13 main models identified were analyzed for evidence, provided by independent researchers, that the associated instruments could demonstrate internal consistency, test-retest reliability, construct and predictive validity. Only one of them was found to meet all four criteria, while two other models met three criteria; three models met two criteria, four models met only one criterion while the rest of three models met none. This brings us to the idea that an implicit learner modeling method, which is based not on the students' answers to questionnaires but on analyzing their learning behavior, could prove very useful and alleviate the weaknesses of the traditional measuring instruments.

Furthermore, some of the criticism is only related to the limitations of the traditional face-to-face education, given the unrealistic burden it would place on the teachers: "It is hard to imagine teachers routinely changing their teaching style to accommodate up to 30 different learning styles in each class, or even to accommodate four" [10]. Obviously, this problem is alleviated in e-learning systems, which have the built-in potential of offering individualized learning paths to the students, with little overhead for the teachers.

A further negative aspect outline in [10] is the theoretical incoherence and conceptual confusion, which comes from the multitude of learning style models available. There is a certain degree of overlap among the concepts used, but no direct correspondence between them and no agreed core technical vocabulary. The field suffers from the lack of an overarching synthesis of the main models.

Another weakness of the learning style models is the danger of labeling or pigeonholing the students, since the temptation to classify and stereotype might be difficult to resist.

On the other hand, while pointing out the limitations, Coffield et al. acknowledge also the benefits of using learning styles, as we have detailed in the previous section: self-awareness and metacognition, a lexicon of learning for dialogue, a catalyst for individual, organizational or even systemic change [10].

3.2 Studies in Technology Enhanced Learning Settings

As far as the field of LSAES is concerned, most of the existing studies reported an improvement in the learning gain and/or student satisfaction: [3], [7], [19], [27], [30], [39], [42], [44]. To the best of our knowledge, there are only three studies that reported no improvement brought up by adaptation to learning styles: [5], [6], [28]. However, as the authors themselves concede, no definitive conclusion can be drawn based on those findings. It could be that better adapted interfaces than those used in the study should be designed, for which different results might be obtained. Or it could be that other dimensions of learning styles, which were not included in the study, might have a greater influence on the learning process. Or it could be that the students used in the study have already been unintentionally pre-selected on the basis of their academic ability, so we may assume that these students can already learn effectively, even when presented with less than optimal opportunities (i.e. a mismatched learning environment) [5].

3.3 Summary of Criticism

To sum up, the most frequently raised criticisms regarding learning styles are:

- There is a very large number of learning style models proposed and there is no unanimously accepted one.
- There is a proliferation of terms and concepts (which sometimes overlap) and there is no mapping between different models (and no agreed taxonomy).
- Dedicated inventories suffer from psychometric weaknesses: some of the instruments used to measure learning styles could not demonstrate internal consistency, test-retest reliability or construct and predictive validity.
- Psychometric instruments can usually be applied only once per student; furthermore it is difficult to motivate learners to fill them out - if they are too long or students are not aware of the consequences or future uses of the questionnaires, they tend to choose answers arbitrarily instead of thinking carefully about them. In addition, the accuracy of self-perceptions is questionable: ”self-perceptions can be misleading and the answers are easy to fake if someone is determined to give a misleading impression” [24].
- Learning styles are not a stable cognitive factor over time or over different tasks and situations.

Apart from the criticism regarding learning styles’ use in traditional learning, we could also add some issues regarding their use in technology enhanced learning. The main problem seems to be that the descriptions of the learning style characteristics are only conceived to cover traditional learning aspects. Present theories are only oriented to the classical way of teaching, ignoring technology related preferences. Therefore learning style questionnaires should be revised and adapted to be used in web-based learning systems. They should be enriched with questions oriented towards specific e-learning aspects, not found in the traditional approach.

4 Unified Learning Style Model - A New Approach

4.1 Rationale

Web-based learning systems that include an implicit and dynamic modeling component alleviate some of the problems identified in the previous section. Indeed, according to many researchers, observations and interviews are more likely than instruments to capture the learning preferences of a student [10]. Thus, implicit learner diagnosing based on analyzing students' interactions with the system can prove more accurate, overcoming issues related to the reliability and validity of the questionnaires, as well as their deficiencies regarding technological aspects. The flexible and evolutionary aspects of the learning preferences are also successfully addressed, since the student model is not static, recorded once and for all, but dynamically updated by the system, based on student's changing behavior. The only limitation is that most of the systems based on implicit learner modeling ([9], [17], [19], [39], [40]) are dependent on a particular learning style model. Consequently, they are still subject to the first two weaknesses outlined in the previous subsection.

This issue regarding the multitude of learning style models and their overlapping has been pointed out by many researchers in the field. Cassidy for example militates for rationalization, consolidation and integration of the more psychometrically robust instruments and models [8]. Gordon and Bull also call for the use of a "generalized model" or "metamodel", in which they included the overlapping characteristics of six of the four quadrant models [18]. Sternberg also ascertains that there is no unifying model or metaphor that integrates the various styles, not only between theories, but even within theories [41].

In this context, our intention is to offer a basis for an integrative learning style model, by gathering characteristics from the main models proposed in the literature. Furthermore, this model is specifically adapted for e-learning settings, by including only those characteristics that meet three conditions: i) have a significant influence on the learning process (according to the educational psychology literature); ii) can be used for adaptivity purposes in a web-based educational system (i.e. the implications they have for pedagogy can be put into practice in a technology enhanced environment); iii) can be identified from student observable behavior in a web-based educational system. Indeed, not all of the characteristics included in a traditional learning style model can be identified through an e-learning system, nor can they be used for adaptation.

Consequently, we propose a Unified Learning Style Model (ULSM), which includes learning preferences related to:

- perception modality: visual vs. verbal
- processing information (abstract concepts and generalizations vs. concrete, practical examples; serial vs. holistic; active experimentation vs. reflective observation; careful vs. not careful with details)
- field dependence/field independence
- reasoning (deductive vs. inductive)
- organizing information (synthesis vs. analysis)
- motivation (intrinsic vs. extrinsic; deep vs. surface vs. strategic vs. resistant approach)

– persistence (high vs. low)
– pacing (concentrate on one task at a time vs. alternate tasks and subjects)
– social aspects (individual work vs. team work; introversion vs. extraversion; competitive vs. collaborative)
– coordinating instance (affectivity vs. thinking).

The above learning preferences were included in ULSM based on a systematic examination of the constructs that appear in the main learning style models and their intensional definitions. In case of similar constructs present under various names in different models, we included the concept only once, aiming for independence between the learning preferences and the least possible overlap. It should be noted that some of the ULSM preferences have a direct correspondent in one dimension of a learning style model, while others represent just one of the traits that characterize a certain style. For example, the field dependent / field independent ULSM characteristic is taken "as is" from Witkin's learning style model [45], including its name and its intensional definition. The active experimentation / reflective observation preference, on the other hand, refers to only a part of the intensional definition of the active / reflective FSLSM dimension [13], not including the attraction towards working in teams (or lack thereof). Actually, this latter preference is included as a separate characteristic in ULSM. Finally, the carefulness towards the details is a ULSM preference which doesn't have any direct correspondent in the traditional learning style models, but it is included as a characterizing trait in many of them (e.g. sequential / global or sensing / intuitive dimension of FSLSM).

4.2 Description of the Unified Learning Style Model

In what follows we will present for each ULSM characteristic the learning style model it was inspired from, together with its intensional definition.

As far as the perceptual modality is concerned, there are many learning style models that include it: FSLSM [13] (visual / verbal dimension), VARK [15] (visual, aural, read/write, kinesthetic), VAK (visual, auditory, kinesthetic), Dunn and Dunn model [11] (visual, auditory, kinaesthetic, tactile), Riding's model [36] (verbaliser / imager) etc. We only included the visual versus verbal preference due to the inherent constraints of a web-based learning environment (in which tactile or kinesthetic preferences are more difficult to accommodate). We also retained the intensional definition provided by FSLSM: visual learners remember best what they see (pictures, diagrams, schemas etc) while verbal learners get more out of words, either spoken or written.

In the processing information family we included several preferences: the abstract concepts and generalizations vs. concrete, practical examples was inspired from Kolb's learning cycle [26] (abstract conceptualization / concrete experience), as well as Gregorc's model [22] (abstract / concrete). The students having the first preference rely on conceptual interpretation, while those having the latter preference rely on immediate experience (apprehension) in order to grasp hold of experience.

The serial vs. holistic preference was inspired from FSLSM (sequential / global) and Pask's model [31] (serial / holist). Sequential learners tend to gain understanding in linear steps, while global learners learn in large leaps, being fuzzy about the details of the subject but being able to make rapid connections between subjects.

The active experimentation vs. reflective observation preference was taken from Kolb's learning cycle (active experimentation / reflective observation), being also present in FSLSM (active / reflective) or Honey and Mumford model [24] (activist / reflector).

The field dependent vs. field independent preference was taken from Witkin's model [45], and refers to the proportion in which the surrounding framework dominates the perception of items within it. Field dependent persons may have difficulty to locate the information they are seeking because other information masks what they are looking for ("the forest rather than the trees") and they are more people-oriented. Field independents find it easier to recognize and select the important information from its surrounding field ("the trees rather than the forest") and are more impersonal-oriented.

The inductive vs. deductive preference was taken from the first version of FSLSM: inductive learners prefer to reason from particular facts to a general conclusion; they respond best to problem based learning or inquiry learning; deductive learners prefer to reason from the general to the specific and they like the course to start with the fundamentals and continue with the applications.

The synthetic vs. analytic preference was not taken "as is" from any learning style model. However, similar concepts can be found in Allinson and Hayes' model [1] (intuitive / analytic) and Riding's model [36] (holist / analytic). A synthetic student has an overall image of the subject and tends to combine elements in order to understand the whole; an analytic student focuses on the parts of a whole or on underlying basic principles.

As far as the motivation is concerned, the deep vs. strategic vs. surface vs. resistant approach was inspired from Entwistle's model [12], to which the "resistant" component was added, which is similar to Grasha-Riechmann's "avoidant" [21] and Vermunt's "undirected" [43]. Students with a deep approach to learning are "meaning-oriented", they want to understand ideas for themselves, they examine logic and argument cautiously and critically and they are actively interested in the course content. Students with a strategic approach are "achieving-oriented", they want to obtain the highest possible grades, being alert to assessment requirements and criteria and gearing work to the perceived preferences of lecturers. Surface learners are "reproducing-oriented", their intention is to pass the exams, they mostly memorize facts, finding difficulty in making sense of new ideas presented, they study without reflecting on either purpose or strategy and they feel undue pressure and worry about work. Resistant learners have a total disinterest towards the course, they refuse to participate to learning activities, they are apathetic and disobedient.

The intrinsic vs. extrinsic motivation approach doesn't have a direct correspondence in a learning style model. It is however related to Entwistle's model, as well as to Apter's telic-paratelic dimension [2]. Students who are intrinsically motivated learn for the sake of the experience alone, while those who are extrinsically motivated learn in order to obtain an external reward.

The persistence level was taken from Dunn and Dunn model (persistent / non-persistent) [11]: the high persistence students have the inclination to complete tasks, spending a high amount of time studying and coming back to the learning material. The low persistence students have a need for intermittent breaks and they rarely come back to the learning material.

As far as the pacing preference is concerned, it was not taken directly from a learning style model. Students who prefer to concentrate on one task at a time have a linear learning path, with seldom jumps and returns; students who prefer to alternate tasks and subjects like to jump frequently from one passage to another, from one course to another.

The preference towards learning individually versus learning in groups is present "as is" in Dunn and Dunn model (learning groups: learn alone vs. peer oriented), and is also related to many other learning style models (e.g. the FSLSM active / reflective dimension, Herrmann's theorist vs. humanitarian [23] etc).

The introvert vs. extravert characteristic is taken from the Myers-Briggs Type Indicator (MBTI) (extraversion / introversion) [29], having correlations with many other models. An introvert learner has the inclination to shrink from social contact and to be preoccupied with internal thoughts and feelings, while an extravert learner has the inclination to be involved with social and practical realities rather than with thoughts and feelings.

The competitive vs. collaborative preference can be found in Grasha-Riechmann's model [21], being also correlated with Apter's concept of autic mastery (which reflects values of individualism and competitiveness) and alloic sympathy (which reflects values of social belonging and cooperation) [2].

The coordinating instance of the learning process (affectivity vs. thinking) is related to the MBTI's feeling vs. thinking. Students whose learning is coordinated by affectivity like to conclude based on intuition and feeling, while students whose learning is coordinated by thinking take decisions based on analysis, logic and reasoning.

It should be noted that we have only included in ULSM those preferences that can be dealt with in a web-based educational system. Other learning preferences, such as those related to the environment (e.g. noise, light, temperature, comfort) or physical dimensions (e.g. time of the day, mobility), can only be catered for in traditional learning settings. Hence, while having an important effect on learning, they are outside the scope of this model.

Of course, learning is so complex that it cannot be completely expressed by any set of learning style dichotomies [37]. Therefore we do not claim that our model is exhaustive; we argue however that the above set of characteristics is a first step towards building an integrative, unified model.

4.3 Advantages of Our Implicit Modeling Method Using ULSM

Firstly, the problems related to the multitude of learning style models, the concept overlapping and the correlations between learning style dimensions are eliminated.

Secondly, the belonging to a learning style dimension is not absolute; rather it takes the form of a stronger or weaker preference. Thus learners may exhibit characteristics from opposite learning style dimensions in a traditional model, e.g. a student might have a strong preference towards actively working with the educational material while at the same time prefer individual work; in this case, with the traditional approach, she/he would have probably been categorized as "balanced" on the active-reflective dimension of Felder-Silverman learning style model, subsequently being considered to have no preference towards either individual vs. team work or simulations vs. theory; using our proposed approach, she/he would be offered the opportunity to both work individually and interact actively with the material. Consequently, another advantage of the ULSM is a simplified and more accurate student categorization (*feature-based modeling*), as opposed to the traditional *stereotype-based modeling*. The validity of our modeling approach was proved experimentally and good precision rates were reported [33].

Furthermore, in traditional learning settings, the use of a single learning style model presents the advantage of creating only a limited number of versions of the same course; however, when using technology enhanced learning, this limitation is removed: the ULSM is able to include a large number of learning preferences, without an increase in the teacher workload. The teacher will have to prepare the same amount of educational materials, which will be dynamically combined according to each student's preferences. Of course, we should point out that not all topics can be taught in all learning styles. As Gardner said about customizing the learning material to fit the seven intelligence types, "there is no point in assuming that every topic can be effectively approached in at least seven ways, and it is a waste of effort and time to attempt to do this" [16]. However, with the use of dynamic adaptation, there is the possibility to accommodate a large number of learning preferences, with little overhead for the teachers, as we have shown in [35].

Finally, since what we store are individual learning preferences, not styles with a positive or negative connotation, there is no danger of labeling or pigeonholing the student. In addition, due to the implicit diagnosing method and the automatic adaptation process, the learning preferences shouldn't necessarily be revealed to either the student or the teacher. This would ensure a complete privacy of the learner and avoid the danger of stereotyping. However, an even better approach would be to educate both the students and the teachers to correctly understand and deal with learning styles. Metacognition and learning style awareness can help students understand their strengths and weaknesses in the learning process and use them to their advantage.

5 Conclusions

In this paper we provided a critical analysis of learning styles and their use in technology enhanced learning settings. As a response to the criticism, we introduced a unified learning style model and theoretically justified its use.

However, our intention was not to propose yet another learning style model, but to provide a pragmatic approach, summarizing those learning preferences that could have a practical use in technology enhanced learning settings. It is therefore worth mentioning that the ULSM model was successfully integrated into a dedicated e-learning platform, called WELSA. The model could thus be validated experimentally, both from the learner modeling and the adaptation point of view. Consequently, in [33] we showed how the characteristics included in ULSM can be identified from monitoring and analyzing learner behavior in a web-based educational system; our implicit modeling method yielded good precision results. In [35] we identified the adaptation technologies that best serve students with different ULSM learning preferences and defined the corresponding adaptation rules; according to the experimental results, adapting the course to the students' ULSM preferences had a positive effect on the learning process in terms of efficiency, learner enjoyment and overall satisfaction [34].

From a theoretical point of view, it would be useful to associate a solid psychometric instrument to the ULSM model, which is one of our future research directions.

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Evaluating the Impact of Adaptation to Learning Styles in a Web-Based Educational System

Elvira Popescu

University of Craiova, Software Engineering Department
A. I. Cuza 13, 200585 Craiova, Romania
popescu_elvira@software.ucv.ro

Abstract. Measuring the effect of providing educational experiences individualized to the learning style of the students is an open research issue. This paper aims at presenting a case study of a dedicated adaptive educational system called WELSA. First, the adaptation logic, methods and techniques employed in WELSA are briefly presented. Next, the validity and effectiveness of the system are assessed by means of an empirical evaluation approach, involving two experiments with 64 undergraduate students. The results obtained (in terms of learner behavior, performance, efficiency and satisfaction) are analyzed and discussed. The overall results of the experimental study indicate a positive effect of adaptation to learning styles on the learning process.

1 Introduction

The goal of adaptive educational systems (AES) is to offer an alternative to the non-individualized instruction approach, by providing various services adapted to the learner profile. The purpose of this adaptation is to maximize the subjective learner satisfaction, the learning speed (efficiency) and the assessment results (effectiveness).

The focus of this paper is on a psychological factor as the adaptation criterion, namely the learning style of the student, since it is one of the individual differences that play an important role in learning [16]. Learning style refers to the individual manner in which a person approaches a learning task, the learning strategies activated in order to fulfill that task.

This paper aims at evaluating the success of adaptation (whether the above mentioned objectives are met or not) in case of a particular e-learning platform named WELSA (**W**eb-based **E**ducational system with **L**earning **S**tyle **A**daptation). In brief, WELSA offers the functionalities of a basic learning management system, enhanced with modeling and adaptation capabilities. Students can learn by browsing through the course and performing the instructional activities suggested (play simulations, solve exercises etc). They can also communicate and collaborate with their peers by means of the forum and chat. All learner actions are logged and analyzed by the system, in order to dynamically identify the learning style of the students (implicit modeling method). Based on the identified learning preferences and the built-in adaptation rules, the system offers students individualized courses (as we will see in the following sections).

The set of learning preferences that WELSA is founded on, called ULSM (Unified Learning Style Model), is extracted from the main learning style models proposed in

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the literature. The extraction process was based on a systematic examination of the constructs that appear in these main models and their intensional definitions; ULSM was conceived to cover a wide range of characteristics, while at the same time aiming for independence between them and the least possible overlap. More specifically, ULSM integrates learning preferences related to: perception modality, way of processing and organizing information, as well as motivational and social aspects; its detailed description can be found in [16].

The rest of the paper is organized as follows: section 2 offers a glimpse into the evaluation issue in AES and summarizes the experimental results reported in similar works. Next the adaptation methods and techniques that are employed in our WELSA system are briefly introduced. The validation of our approach is presented in section 4, by means of an experimental study involving 64 students in Computer Science; both an objective evaluation and a subjective one are performed, by analyzing the behavior of the students in the system and their answers to opinion questionnaires respectively. Finally, section 5 provides some discussions and concluding remarks.

2 Evaluation Methodology and Related Works

Empirical tests and evaluations are of a particular importance in the field of adaptive systems, as outlined in [22]. The most widely used evaluation approach of an AES is to compare it with a non-adaptive version of the system (with the adaptation mechanism turned off). The evaluation can be done in respect to three factors: i) subjective student satisfaction; ii) learning speed (efficiency); iii) assessment results (effectiveness). Thus the criteria that can be used in the evaluation are: learners' scores in knowledge tests, the time learners spent on the course, the number of their page requests, the number of returns to the same page (getting lost feeling), the eagerness to work with the system etc.

On the other hand, it can be argued that a successful adaptation does not necessarily imply acceptability from the part of the user [4]. The main reason is that adaptive applications can make the user feel he lost control of the application. This is why AES should be able to justify their decisions and also give learners access to directly modify their profile, if desired. Moreover, the privacy and security of the information stored for the learner must be carefully considered, or the learner might loose her trust in the application. Thus adaptation should not be seen as a goal in itself, but as a way of improving the effectiveness of the system. In this respect, assessing student satisfaction by means of questionnaires is a very important step in the evaluation of an adaptive educational platform.

Finally, it should be taken into account the degree of influence of each factor in the learning process: obviously, reinforcement, student's prior cognitive ability, student's disposition to learn, and the instructional quality have bigger influence on the effectiveness of learning than the individualization of instruction to conform to student's learning style [7]. Therefore the obtained data should be carefully analyzed and interpreted.

As far as the field of Learning Style-based Adaptive Educational Systems (LSAES) is concerned, most of the existing studies reported an improvement in the learning gain and/or student satisfaction: [1], [6], [9], [10], [13], [18], [20], [21]. To the best of our knowledge, there are only three studies that reported no improvement brought up by adaptation to learning styles: [2], [3], [12]. However, as the authors themselves concede, no definitive conclusion can be drawn based on those findings. It could be that better adapted interfaces than those used in the study should be designed, for which different results might be obtained. Or it could be that other dimensions of learning styles, which were not included in the study, might have a greater influence on the learning process. Or it could be that the students used in the study have already been unintentionally preselected on the basis of their academic ability, so we may assume that these students can already learn effectively, even when presented with less than optimal opportunities (i.e. a mismatched learning environment) [2].

In this context of contradictory experimental findings regarding LSAES, we believe that exposing the results obtained by assessing the value of our own system, WELSA, is a worthwhile endeavor. We begin by a brief presentation of the adaptation logic and techniques used in our system.

3 Overview of Methods and Techniques for Providing Adaptivity in WELSA

Our pedagogical goal was to offer students recommendations regarding the most suited learning objects and learning path, but let the students decide whether they want to follow our guidelines or not. Offering control to students has several advantages: first of all, in case the learning style preference identified by the system is not accurate, the students can ignore the system recommendations and consult the learning objects that they feel are most suitable for them and in the order that they judge appropriate. Second, there may be students who prefer to study the course extensively and so they should have access to all the additional learning objects. Furthermore, imposing a course structure or order to a student may make them feel frustrated and/or confused, especially when they have a chance to compare their version of the course with their peers'. Finally, in the context of an experimental study (as is our case), allowing the student to choose whether to follow our recommendations or not gives us a measure of the success of our adaptation (i.e. whether the adaptation corresponds to the actual needs of the students).

Due to the above reasons, we decided to rely on sorting and adaptive annotation techniques rather than direct guidance or hiding/removing fragments (according to the classification proposed in [5]). We also decided to use the popular "traffic light metaphor", to differentiate between recommended learning objects (LOs) (with a highlighted green title), standard LOs (with a black title, as in case of the non-adaptive version of WELSA) and not recommended LOs (with a dimmed light grey title).

A detailed presentation of the adaptation rules and techniques employed in WELSA, as well as the implementation of the adaptation mechanisms are included in [17]. In what follows we will show an example of the way these adaptation strategies are visualized by the students, in the Web browser. The example is taken from an Artificial Intelligence course, more specifically the chapter on Constraint Satisfaction Problems (CSP).

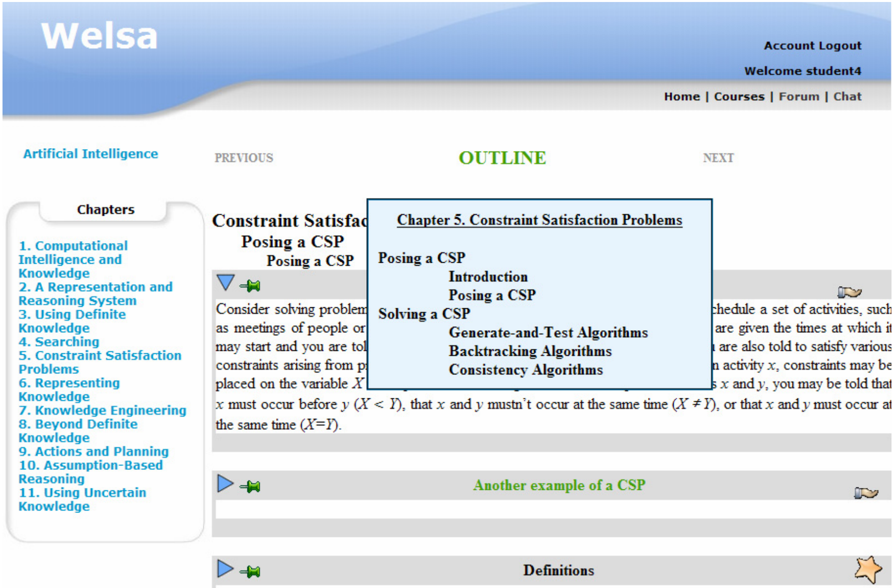

Fig. 1. A snapshot from the WELSA system, with a course page adapted for a student with *Concrete* and *Holistic* learning preferences

Figure 1 shows the course page on "Posing a CSP", which starts with two recommended examples followed by a definition, since the student for which the page was generated has a *Concrete* learning preference (and therefore she prefers abstract concepts to be first illustrated by practical examples). Since the learner also has a *Holistic* preference, she is advised to access the chapter Outline (which is highlighted and presented in an expanded form in Fig. 1); in this way, she will be able to initially grasp the big picture of the course and make connections with related subjects.

4 Evaluation of the Adaptation Approach

4.1 Experiment Settings

In order to assess the effect of adaptation on the students, we used the traditional "with or without" approach, by performing two experiments involving 64 undergraduate students: one in which they interacted with the non-adaptive version of WELSA and one in which they interacted with the adaptive version of WELSA. The course followed in the first experiment dealt with "Searching and solving problems by search", while the one in the second experiment was concerned with "Constraint satisfaction problems"; both course modules were inspired from the classic AI textbook by Poole, Mackworth and Goebel [14] and were implemented in WELSA.

For the adaptive version we took into consideration two possible approaches: i) provide students with an educational experience that corresponds to their learning preferences; ii) provide students with an educational experience that is contrary to their preferences. We therefore split students in two groups: one which was provided with a matched version of the course (further referred to as ”matched group”) and one which was provided with a mismatched version of the course (further referred to as ”mismatched group”), with respect to the students’ ULSM preferences. The identification of the students’ learning preferences was realized by means of students’ self-diagnosis (explicit modeling method) and by analyzing their behavior in the system (implicit modeling method), as detailed in [15].

The experiment scenario was similar for both sessions: first, the students had two hours to browse through the course; next they were asked to take an assessment test and then to fill in a questionnaire in which they could state their opinion on the course, the navigation paths they have taken, the effectiveness of the adaptation, the degree of satisfaction with the course etc.

Since we used the same subjects for the adaptive and non-adaptive sessions, we were able to perform both an intrasubject and an intersubject comparability study. In order to evaluate the adaptation process, we used two kinds of data: i) the behavior of the students in WELSA, as monitored and logged by the system (reported in subsection 4.2); ii) the students’ opinion about the adapted course, as stated in the questionnaires (reported in subsection 4.3).

4.2 Analyzing Behavioral Indicators

We investigated the following behavioral indicators, as they were recorded in the adaptive session:

- total learning time - *t_total*
- total number of hits on LOs - *n_LO*
- grade obtained on the evaluation tests - *grade_tests*
- time spent on recommended versus not recommended LOs - *t_recommended_rel*
- number of accesses of recommended versus not recommended LOs - *h_recommended_rel*
- number of LOs accessed in the recommended versus not recommended order - *n_recommended_sequence_rel*
- number of recommended versus not recommended navigation actions - *n_recommended_navigation_rel*

First we computed the above values using the Analysis tool incorporated in WELSA. Next we performed a statistical analysis on the data, comparing the values obtained for the matched and mismatched groups in order to find significant differences. t-test was applied when the data were normally distributed and u-test when the data did not follow a normal distribution (the normality was checked with the Kolmogorov-Smirnov test). The tests were applied using SPSS software package [19]. The results are presented in Table 1, including only those values for which we obtained statistical significance ($p < 0.05$). The mean values for each of the learning patterns, as well as t, u and p values are included.

Table 1. Comparisons of pattern values for matched versus mismatched groups

Learning pattern	Matched group mean	Mismatched group mean	t-test / u-test
t_total	90	105	$t = -2.03$, $p = 0.026$
n_LO	45	58	$u = 123.00$, $p = 0.039$
t_recommended_rel	3.7	0.54	$t = 3.05$, $p = 0.002$
h_recommended_rel	2.12	0.73	$t = 2.11$, $p = 0.023$
n_recommended_navigation_rel	2.25	0.55	$t = 2.31$, $p = 0.015$

The results obtained are very encouraging: the matched adaptation approach increased the efficiency of the learning process, with a lower amount of time needed for studying and a lower number of randomly accessed resources (lower level of disorientation). The effectiveness of the matched adaptation and its suitability for addressing students' real needs are also reflected in the statistically significant higher time spent on recommended versus not recommended resources, as well the higher number of accesses of those recommended learning objects. Finally, the recommended navigation actions were followed to a larger extent than the not recommended ones.

The only two patterns for which we did not obtain a statistically significant difference are *grade_tests* and *n_recommended_sequence_rel*. The fact that we did not obtain a significant increase in the learning gain was expected and is consistent with other studies [9]. However, it should be noted that this is also due to the following facts: i) only one 2-hour adaptive session took place; constantly applying a matching or mismatching approach could lead to more significant results; ii) students had the chance to access all LOs if they chose to do so, which means that a mismatched student could eventually access all the LOs that match her/his style, maybe with some loss of time and satisfaction.

Regarding the number of LOs accessed in the recommended order versus not recommended order (*n_recommended_sequence_rel*), not obtaining a significant difference can be explained by the fact that a large majority of the students chose the order provided by the system, whether matched or mismatched. Further explanations for this behavior are offered in the next subsection.

So far we presented the objective measures of learner behavior in the system. Next we will analyze the students' subjective estimation of these parameters and their perceived effectiveness, efficiency and overall satisfaction.

4.3 Analyzing Students' Answers to Questionnaires

Perceived Difference between Adaptive and Non-Adaptive Sessions. One of the first goals of our questionnaire was to identify the difference between the adaptive and non-adaptive course sessions, in terms of learning gain, enjoyment, efficiency, learning effort, motivation and degree of satisfaction, as perceived by the students. Each of the 6 features was evaluated by the learners on a 3-point-scale and the results are presented in Fig. 2. Furthermore, for each question the students had the possibility to justify / comment on their answers.

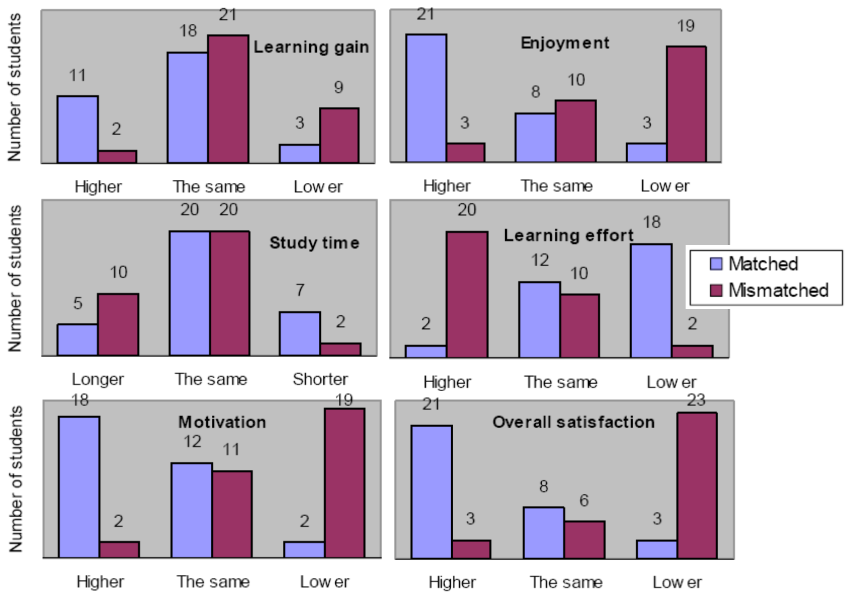

Fig. 2. Comparison between the perceived learning gain, enjoyment, study time, learning effort, motivation and overall satisfaction in the adaptive versus non adaptive sessions

As we can see from Fig. 2, the greatest improvements between the adaptive and non-adaptive sessions were perceived by the students in the matched learning group in terms of enjoyment (65.63%), overall satisfaction (65.63%), motivation (56.25%) and learning effort (56.25%). At the same time, students in the mismatched learning group reported lower levels of overall satisfaction (71.87%), enjoyment (59.38%), motivation (59.38%), as well as an increase in the learning effort (62.5%). The differences in the learning gain and study time were less clear cut: only 34.37% of the matched students described an increased learning gain and only 21.87% a reduced study time. Conversely, 28.12% of the mismatched students reported a decrease in the learning gain and 31.25% a longer study time.

The fact that more than half of the students reported a similar learning gain after the adaptive and non-adaptive sessions (56.25% of the matched learning group and 65.62% of the mismatched learning group) could be explained by the other factors that influence learning gain: all students were motivated to learn as well as possible in both sessions, since they were told that the grades of the evaluation tests would count for their final AI grade. Therefore they chose to spend more effort and more time to study, even if they found it less enjoyable. Moreover, it is important to note that the mismatching took the form of recommendations, not rigid prescriptions - all the resources were available to all the students, who were free to choose the less recommended resources if they felt they were more suitable. However, when students are not under observation, are less compelled to study and are presented only with the mismatched learning content, the mismatching can prove more disturbing, making the students lose interest in the subject more quickly.

Degree of Following System's Recommendations and Perceived Usefulness of These Recommendations. The next goal of our questionnaire was to find out the proportion in which students followed the system's recommendations and whether they liked the form of these recommendations (i.e. the adaptation techniques that were proposed to them: ordering, resource annotation etc). The first question was whether the students chose to access the resources in the order in which they were included in the page or in a different one and why. The results are conclusive: the vast majority of the students (87.5%) accessed the learning material in the order in which it was presented to them, whether they were in the matched or mismatched group. The justifications of the chosen order are pretty similar: "because I thought the course was intentionally ordered in this way", "because it seemed normal to follow the order proposed by the person who made the course", "out of convenience", "I didn't like the fact the course started with definitions and theory - I would have understood better if there were some examples first. But since this was the order proposed by the teacher, I thought I should follow it." The fact that students unthinkingly chose to follow the proposed order because "teachers know better", despite their own preferences, confirms the importance of an appropriate ordering of resources. Even if students have the possibility to choose their preferred order, the less experienced ones will rely on the choice already made for them by the course author. These statements come to confirm the importance of the ordering of resources, something that can be so easily achieved by means of adaptive hypermedia, but is so easily overlooked. It should be mentioned that this question referred to the *initial* order of accessing the resources. Of course, some students mention that later they do come back to certain resources, for clarification or for more details (which is also reflected in the recorded behavioral patterns). However, it is the initial impression created by the learning material which is of a particular importance, especially for the less motivated and less perseverant students: it could make the difference between going on with the study or dropping out.

Next we were interested in finding out the degree to which the adaptivity techniques that we employed were perceived as useful by the students: "Did you find useful the fact that the resources were marked as recommended / less recommended?" Not surprisingly, 81.25% of the matched students considered the annotations useful, as compared to only 15.62% of the mismatched students.

Discussion. From the above data, we can conclude that in case of the students who participated in our experiment, following a course that is contrary to their learning style may have a hindering effect on learning. While providing a variety of learning materials, in order to cover all the learning preferences can be a solution, it also increases the cognitive overload of the student, thus not being always recommended. In this case, according to our study, offering the student the course that best matches her/his learning preferences furnishes the best results. These findings are also reflected in the matched students' eagerness to adopt WELSA system for everyday use, with 87.50% willing to do so.

Evidently, the level of satisfaction offered by the adaptive system should be corroborated with the level of importance students attribute to learning style adaptation. Indeed, an educational platform is effective only when the features it offers are both valuable and satisfactory for the learners [11]. We therefore asked the students to assess the importance they grant to having the courses adapted to their learning styles. The results show a large majority of the students (90.63%) who perceive learning style adaptation as highly important.

5 Conclusions

The overall results of the experimental study proved the positive effect that our adaptation to learning styles has on the learning process.

The study also underlined the importance of using fragment sorting (i.e. resource ordering), one of the simplest adaptive hypermedia techniques, but as it turns out, also one of the most efficient. This technique also implies the least amount of work from the part of the teacher, who only has to ensure that the examples / exercises / simulations etc are formulated as independently as possible from the fundamentals they complete. This overcomes also one of the disadvantages of the vast majority of textbooks and courses, which are structured in a deductive way, starting with the fundamental and proceeding to applications [8]. Obviously, there are cases in which changing the order of the learning content is not desirable and does not correspond to the inherent structure of the subject to be taught; in this case the resources should be presented in the predefined order only, independently of the student's preferences.

It should be mentioned also that this experiment was performed with second year students, who had little experience with Web-based educational systems and therefore preferred to be guided during their study. Perhaps more advanced students would know better how to organize their learning path and would also benefit from the challenging advantages of the mismatched adaptation strategy. Further studies are required to validate this hypothesis.

Moreover, in order to allow for generalizations, the adaptation methods should be tested on a wider scale, with users of variable age, field of study, background knowledge and technical experience. Therefore, repeating the experiments for longer periods of time and with a larger number of students is one of our future research directions.

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Task Patterns as Means to Experience Sharing

Benedikt Schmidt and Uwe V. Riss

SAP Research CEC Karlsruhe,
Vincenz-Priessnitz-Strasse 1, 76131 Karlsruhe, Germany
{benedikt.schmidt,uwe.riss}@sap.com

Abstract. Task Patterns are designed as means of activity-centric sharing of knowledge work experience. They are seamlessly integrated in a semantic infrastructure that help preserve the work context and enables a Task Pattern life-cycle. This paper presents a service oriented approach towards Task Patterns. We introduce Abstraction Services, Decisions and Problems as elementary services that support task execution in knowledge work. The Task Pattern approach has been realized on the NEPOMUK Social Semantic Desktop (SSD) to demonstrate the integration of experience sharing and re-use in a knowledge work context.

1 Introduction

Sharing work experience in knowledge work is difficult, as knowledge work is largely self determined, ad hoc, and difficult to trace [8]. Nevertheless, we can find an apparent demand to distribute knowledge on work experience within a knowledge worker community [3]. From an individual point of view a demand for task execution support may arise due to a lack of knowledge or the occurrence of unforeseen problems. From an organizational point of view the distribution of execution knowledge is required to mitigate effects of employee fluctuation [17]. A method to deal with this situation is to support the creation of best practices for task execution as a community process. Thus we can increase knowledge work process maturity within the organization.

We propose Pattern-based Task management as an activity-oriented approach to support the transfer of task execution knowledge based on shared experience in knowledge work. This approach explicitly addresses the individual and ad hoc nature of knowledge work tasks. By combining different support mechanisms, such as services that provide abstract information, examples and lists of problems with solutions, Task Patterns are designed as guidelines for task execution. They originate from the execution of real tasks and are enhanced by the community of knowledge workers which makes use of them. By embedding them in a task-centric information system Task Patterns realize a life-cycle of retrieval, use and enhancement like the Experience Management Model [1].

This paper is structured as follows. First, we present task management on the NEPOMUK SSD which has been extended by Task Patterns. Second, the design of Task Patterns using Abstraction Services to represent basic working activities on different abstraction degrees is introduced. Third, we describe the

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Task Pattern life-cycle and its integration in knowledge work. Finally, different approaches for experience sharing are used as standard for comparison to discuss the Task Pattern approach presented in this paper.

2 Task Management on the NEPOMUK SSD

The Task Pattern approach has been developed on the NEPOMUK SSD [4] and is based on the Semantic Task Management Framework (STMF) [11]. This framework allows a seamless semantic integration of information objects and task representations. We see this integration as a central precondition of the Task Pattern approach. The STMF serves as the central infrastructure that offers web services to desktop applications in order to incorporate task management (TM) functionality.

As the central TM application that uses the task services of the STMF we have developed the KASIMIR sidebar for personal task handling [6]. It shows tasks that emanate from different desktop applications, i.e., it provides a consolidated overview of all available tasks on the desktop. KASIMIR gives users an overview of their current tasks and allows them to assign basic properties, involved persons, used information objects, links, and subtasks as task resources which the user regularly needs during the task execution (see Fig. 2). While the task overview is provided in the upper half of the sidebar the lower half shows the task resources of a selected task. A central goal of the Task Pattern approach has been to integrate the Task Pattern management directly into KASIMIR so that the patterns can be directly used to support the task execution.

3 Concept: Task Patterns for Experience Sharing

Task Patterns have been introduced as a method to support individual task execution and to realize tool-supported experience sharing in knowledge work [12]. Task execution involves the complex interplay between information and work activities [14] in a specific way. Although knowledge work is rather contingent it also includes re-occurring tasks and task schemas, such as planning of business travels or introduction of new employees. This shows that, tasks include systematic and individual aspects: systematic, as a core set of activities will occur in all execution processes, and individual, as each case is slightly different and may include certain problems [13] which demand specific activities. These aspects complicate the sharing of experience, as the identification of schemas is a difficult issue, therefore Task Pattern need to interact with an externalized representation of tasks as information source, as e.g., given by task management systems. Task Patterns reflect the systematic as well as individual dimension of tasks. They allow users to directly identify all necessary building blocks of a task, e.g., if a permission by the management is required for the travel planning or a list of preferred company partners for a flight and hotel are needed.

Users can retrieve Task Patterns for a specific task from an organizational Task Pattern repository and use it to instantiate a newly created task in the system. Instantiation means that the Task Pattern is used to identify aspects of work and information activities which get directly realized in the new task in form of subtasks or attached information objects.

All interaction activities of the user with the Task Pattern and the newly created task are tracked, e.g. which objects get attached to a task following Task Pattern proposals, which elements of the Task Pattern are ignored in the task context etc. This information is used to calculate the relevancy of the Task Pattern information or enhances the Task Pattern by attaching additional information to the pattern. Two different types of enhancement have been integrated into the Task pattern concept:

– *Explicit Enhancement:* The most valuable enhancement of a Task Pattern results from the user decision of contributing his experience to Task Patterns. Even if the enhancement process is supported, explicit enhancement requires high user effort.
– *Implicit Enhancement:* The user interacts with Task Patterns by instantiating them within a task context. This interaction reveals information about a Task Pattern and can be re-used to enhance the Task Pattern without requiring additional user effort. Implicit enhancement can be realized by rules which attach new information to Task Patterns based on the instantiation of tasks.

The combination of these enhancement types increases the Task Pattern maturity each time, the Task Pattern is used in the context of a task. The enhanced Task Pattern is accessible to other users without additional effort, using the Task Pattern repository. The interplay of Task Pattern retrieval, use and enhancement realizes a Task Pattern life-cycle [10].

3.1 Task Pattern Elements

Task Patterns have four different ways to transfer information: Exemplary Tasks, Abstraction Services, Decisions pointing to Abstraction Services and Problems and associated Solutions relating to Abstraction Services (see Fig. 1). Users select a suitable Task Pattern to a new task in terms of the task goal. Having selected a Task Pattern the user can apply the provided Abstraction Services and check Decisions as well as Problems pointing to Solutions clarified. In the following we explain how this is realized in detail.

Abstraction Services: The Abstraction Services that are attached to a Task Pattern provide information that helps users identify basic activities or resources to be used in their task. As such Abstraction Services support the context dependent information acquisition. There are three basic types of Abstraction Services. (1) Information Abstraction Services and (2) Person Abstraction Services guide activities on information objects and recommend possible collaborators required in the task context. (3) Subtask Abstraction Services suggest suitable subtasks that can be executed independently as proper tasks. As such they can make use of other Task Patterns. Subtask Abstraction Services point to potential subtasks, these can make use of other Task Patterns. Thus Abstraction Services

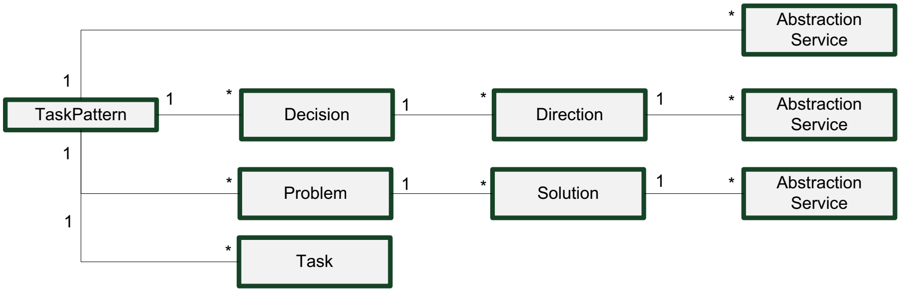

Fig. 1. Task Pattern elements: Tasks, Abstraction Services, Problems with Solutions, Decisions with Directions

allow a guided decomposition of a task. A Task Pattern solves a core problem and points to other Task Patterns via Subtask Abstraction Services for subordinate problems. Like puzzle-pieces different problems are identified and solved using interconnected patterns.

Thereby Abstraction Services give meaning to potential information objects in the task context. They support the re-use, creation or retrieval of the specific type (Person, Subtask, etc.). Therefore they combine a variety of information to allow a flexible description on three different abstraction levels: recommendation, example and abstract description with retrieval support. Recommendation means that information objects are attached to a Task Pattern and proposed for re-use. Example means that information objects are attached to a pattern which cannot be re-used directly, but help to understand the concept which demands an abstraction process on the side of the task executor. An abstract description means that a given purpose and a conceptual description of an information object or an activity is given. Based on the data accessible by the task management system this information can be used to initiate a retrieval process. E.g., an Abstraction Service can propose the person *Dirk*, an Abstraction Service can include Dirk as example for a Person with similar skills or it can list the skills “Quality Engineering and Requirements Engineering” which help to retrieve a person with the specific capabilities. These three abstraction levels integrated into the Abstraction Service types allow a flexible support of Task Pattern instantiation.

Decisions as filter: Similar tasks often require similar decisions with action alternatives. These aspects are also covered by Task Patterns. The decision directs the activities into a specific direction. The corresponding action alternatives consist of several specific Abstraction Services where the alternative is realized by a filter function for these Abstraction Services. The selection of an alternative leads to a filtering of the offered Abstraction Services, pointing to those which are relevant to the made decision. For example, in the business travel case a decision in a Task Pattern might offer the alternatives to travel by *plane* or *train*. Once the task performer has decided for *plane* the Abstraction Services related to *train* are no longer offered to the task performer.

Problems and Solutions: Knowledge work is often characterized by unforeseen situations which require particular handling. Aid in these cases is especially needed if the task performer lacks experience. Therefore Task Patterns provide a list of known Problems for such situations if they occurred during the execution of similar tasks. Each Problem can be associated to different Solutions. Problems and Solutions are given as short textual descriptions. The Solution additionally includes a description of the necessary activities. These activities are supported by suitable Abstraction Services. This allows the task performer to build up problem awareness and supports their solution of actual problems.

4 Task Patterns in KASIMIR

Task Patterns extend the Task Management functionalities of the SSD and are part of the integrated KASIMIR user interface. One KASIMIR view allows the retrieval of Task Patterns supported by filter mechanisms and gives a quick overview of the available Task Patterns. A Create/Edit Task Pattern view allows the creation and the explicit enhancement of Task Patterns, e.g. as semi-automatic transformation of an existing task into a Task Pattern. The Task Compare view allows to make use of the Abstraction Services of a Task Pattern which has been assigned to a respective task. In the following, we present the Create/Edit Task Pattern view and the Task Compare view in detail.

4.1 Create/Edit Task Patterns

The Create/Edit Task Pattern View (Fig. 2) provides functionalities to maintain Task Patterns and related objects like Abstraction Services, Decisions with Directions and Problem with Solutions. It allows the automatic transformation of task instances to Task Patterns and consists of four basic elements. The left side of the interface describes the elements of a Task Pattern: In the upper part the name and a description of the Task Pattern can be entered. The middle part shows all Abstraction Services, Decisions/Alternatives and Problems/Solutions in a tree view. The Abstraction Services, Decisions/Alternatives and Problems/Solutions are grouped by their type and can show details like the attached instances, tags, predecessors etc. The lower part of the left side shows all tasks which are attached to the Task Patterns: tasks which used the Task Pattern and contributed to it. New tasks can be associated and associations can be removed. The right side of the interface gives a detailed overview of the connected tasks and their use contexts to the user. In a tab view the user can select one of two possible views: an object view grouping attached objects by type or a task journal view showing the temporal relation of attached objects as presented in [13]. Such additional task information gives an overview of the different tasks belonging to the task class described by a Task Pattern.

The main user interface of KASIMIR shows a list of user tasks (Fig. 3 - left side). In the lower part different context views for the selected task can be chosen in a tab-view. One context view is the Task Compare View which supports the

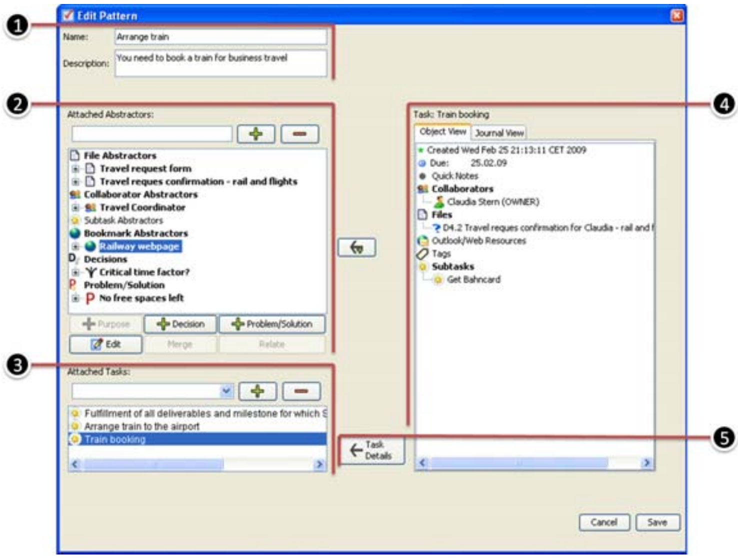

Fig. 2. Create/Edit Task Patterns. (1) Edit Task Pattern Name and Description (2) Edit Abstraction Services, Decisions and Problems (3) Edit Tasks Attached to Task Pattern (4) Details to selected Task (5) Hide Details to selected Task.

instantiation of a Task Pattern by juxtaposing task as instantiation with Task Pattern as abstract scheme. The view stresses the correlation of both and allows the identification of shortcomings in the task as well as in the Task Pattern. Functionalities to re-use knowledge included in the Task Pattern and to enhance the Task Patterns using task resources allow to remedy such shortcomings. The Task Compare View (Fig. 3 - right side) shows the application of a Task Pattern in a task. In the upper part of the screen (Fig. 3 (1)) name and description of the attached Task Pattern are visible to get a quick overview. The task performer can review the rating of the pattern and give a rating by selecting between one and five stars. Using the "edit"-button the task performer can open the Create/Edit Task Pattern screens (Fig. 2). Buttons for Decisions and Problems are placed next to the Create/Edit Task Pattern button. They open context menus to get help on actual problems and to make decisions for the task. The lower part (Fig. 3 (2)) lists the objects of the task and of the Task Pattern in a tree-table grouped by the information object type they represent. For each object type the according Abstraction Services and information objects of the tasks are listed in table rows. If an information object represents the concept of an Abstraction Service they are in the same row (Fig. 3 (6) and (7)). If an information object is not related with a corresponding Abstraction Service in the Task Pattern or an Abstraction Service is not related with a corresponding information object the respective column is empty (Fig. 3, (4) and (5)). This suggestive view supports the identification of differences between task and Task Pattern and demands interaction using the context menu. The context menu allows the user to

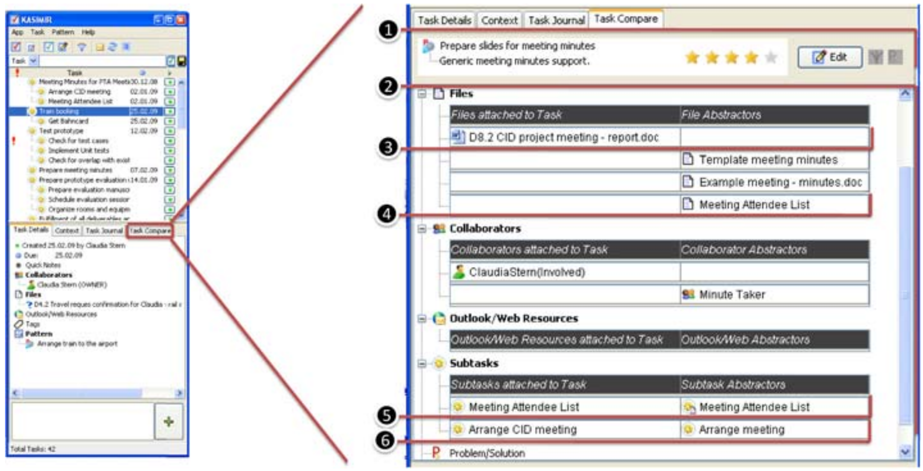

Fig. 3. Task Compare View. (1) Task Pattern Specification (2) Task Pattern Details Tree Table (3) Abstraction Services without Object (4) Object without Abstraction Service (5) Document Abstraction Service Subtask (6) Abstraction Service with Instance.

directly transform information objects into Abstraction Services and supports the re-use of information objects attached to the Abstraction Service as well as the retrieval of objects which are described by tags. The tags support object retrieval in the data structure of the SSD. Additionally Information and Person Abstraction Services can be used as subtasks, if the transferred information has process-characteristic to the task performer (Fig. 3, (6)). All activities are tracked to generate information about the re-use of information attached to the Task Pattern and realize the implicit Task Pattern enhancement.

5 Related Work: Towards Experience Sharing

Task execution support in knowledge work has been in the focus of different research projects. Many approaches share experience based on task execution knowledge captured in task-centric information systems. Mostly two different types of experience sharing are realized: task objects with subtasks and attached information objects are used as templates or abstractions of such templates realize process-like representations of task execution.

The Task Navigator [7] combines task-oriented proactive information delivery and tool support for task management. Proactive information delivery means recommendations of information objects based on former task execution. Additionally users can make use of tasks as templates or use process-like description of tasks (process-types). Proposals and the re-use of tasks and process types are embedded as recommendation lists into tree-like task structures.

The Collaborative Task Manager provides a framework for modelling, exchange and re-use of light-weight, user-defined task structures. The structures represent agile, human-centric business processes which emerge from user-defined tasks, attached subtasks, information objects and task delegation. The system provides techniques to manually refine tasks in form of Task Patterns and enables a process flow representation of tasks [16]. Compared to the approach introduced here minor user support during the creation and re-use of Task Patterns is given due to the missing semantic integration to describe context and purpose of objects in a task context.

An approach to support task execution by non-prescriptive guidelines has been proposed in the context of the Unified Activity Management project (UAM) [9]. Activity Patterns have been proposed as dynamic structure to disseminate task execution knowledge in terms of activities. Aspects of this concept have been realized as activity templates in Lotus Notes Activities [5]. Activity templates can be created by domain experts or be created based on earlier task execution. They describe activities necessary to execute a task. The template provides placeholders which stand for objects used in the task context. Placeholders lack the contextualization of information objects on different abstraction levels. Additional knowledge collected by the community requires additional maintenance effort to be included in the activity template. Although, the direct re-use of such knowledge to enhance an activity pattern has been proposed in [2] it has not been realized beyond the presented paper-based user study.

The given overview shows the difficulty to find a useful abstraction level for task execution support. Templates based on individual tasks are often too case specific, while process-like descriptions are too formal. Such templates give users support in form of listed subtask and information object recommendations for task cases and complicate identification of purpose and context. Process models are represented by complex flow-charts which fail to adequately represent the flexible nature of task execution and often overstrain the individual user. Different support techniques combined in one system complicate the retrieval and re-use of task execution knowledge. The presented approach avoids such differences by relying on one single concept: Task Patterns with Abstraction Services which can model different abstraction degrees, as Abstraction Services are capable to include conceptual information, information objects and information retrieval support. The Activity Pattern approach of the UAM project provides an alternative of task knowledge re-use and abstraction without relying on process descriptions, but lacks a concept to distribute this knowledge to the user and a realization as software.

6 Discussion

We have discussed Task Patterns as structures to share task execution knowledge. The SSD with task management functionalities and a data model which combines process knowledge and information object has been chosen as basis. It supports implicit Task Pattern enhancement and the transformation of tasks into Task Patterns. An important aspect of the given approach is the introduction of Abstraction Services. We see them as means of the Task Patterns that contextualize experience sharing in knowledge work. The presented Task Pattern approach realizes a life-cycle based on information captured during Task Pattern instantiation. This process is fostered by the Task Compare view which seamlessly integrates task organization and task execution support. It points to elements of a core execution process using Abstraction Services, Problems with Solutions and Decisions with Directions and allows the direct instantiation of a Task Pattern for a task.

The Task Pattern life-cycle increases Task Pattern maturity based on implicit and explicit enhancement. Life-cycle and enhancement processes are fostered by the instantiation of Task Patterns in the Task Compare view. This goes beyond recommendation lists for relevant information objects and avoids process model representations: it uses a simple representation based on comparison. The Task Compare view suggests the re-use of abstract information and tracks user decisions for the task case, as certain information object get related to Abstraction Services, information-retrieval processes are initiated based on tags, Problems are activated or Directions are chosen. This hints to the re-use for different information attached to a Task Pattern.

The realization of Task Pattern not only facilitates knowledge application and transfer (single-loop), but it also provides a framework on which double-loop learning can be realized as already discussed in [10]. The individual single-loop focuses on task execution, personal reflection and adaptation but lacks critical reflection due to the pace and nature of knowledge work. By sharing Task Pattern collective reflection creates a multi-perspective approach to analyzing and questioning task execution methods within a community of practice.

The represented Task Pattern approach has been evaluated in a long term user study with 13 participants who used task management and the SSD in their daily work. The study is described in detail in the forthcoming project deliverable of the NEPOMUK project: [15]. As a result, the study showed that the complexity of Task Patterns complicated the interaction with the user interfaces and demands a further simplification of the interaction mechanisms. Nevertheless, Task Patterns were considered as a useful means to support reoccurring activities. In particular the social aspect of Task Pattern handling was clearly recognized by the users. Development on Task Pattern will be continued to solve the usability issues.

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Effectively Managing and Processing Personal Learning Content

Stefanie Sieber and Andreas Henrich

University of Bamberg, Faculty of Information Systems and Applied Informatics
Chair of Media Informatics, Feldkirchenstr. 21, D-96052 Bamberg, Germany
{stefanie.sieber,andreas.henrich}@uni-bamberg.de
http://www.uni-bamberg.de/minf

Abstract. Comparing the typical learner only about one or two decades ago and today, an undeniable difference is evident. By now, most of traditional learning has been moved into a continuum of blended learning, as defined by Jones [1]. In this context, especially ways for distributing learning material and contacting each other have completely changed. Learning Management Systems (LMS) are, in the majority of cases, employed to provide a basis for modern learning. Whether it comes to distance learning or not, all required material, including additional information for further reading and tasks controlling the learner's success, is provided online such that learners can easily access all desired information any time and any place. Communication has been detached from specific points or periods in time as well. This digitalization of the learning process also bears new challenges, which have to be faced by learners as well as lecturers.

The concept, introduced in this paper, addresses these facts by delivering a service to set the stage for a personal learning environment adjusted to the needs of a single user. Hence, it provides facilities for integrated maintenance and search in heterogeneous personal learning material.

1 Vision and System Characterisation

Briefly summarized, our experiences with LMS (cf. [2]) and their functionalities, often far from being satisfactory, lead us to proposing this system as described—especially if the shift from an institutional to a learner's perspective is desired. The vision of this approach basically lies in the provision of an environment, allowing a single user to administer his learning material including the corresponding learning context in order to facilitate learning insights. To get an idea of the scenario this system intends to support, just imagine the following picture:

A student is attending a lecture. As usual the lecture introduces different concepts, varying in depth. So, preparing and postprocessing the lecture, the student spends time collecting and browsing related information. This includes administrative tasks like downloading the provided slides for the lecture and going through his personal notes, but also following forum discussions on today's

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lecture or browsing additionally prepared link lists. Of course, it is also likely that our student searches the Internet for more information and—glancing over the first hits—stumbles across an article containing interesting insights.

A few weeks later, our student is attending a preparation group to study for the upcoming exam and realizes that he has some urgent work left in different areas of the lecture, because he is not as familiar with all details as he should be. He remembers that he already glanced through a good summary—one of the articles mentioned above—a while ago. Unfortunately, his first thought—to find the information in the slides provided for the lecture—turns out wrong. Also he does not have any additional locally saved files including the desired information. Logically he is now trying to find the particular information he is remembering only vaguely, knowing this is exactly what he is looking for. Next on the list could be a visit to and search in the course forums dedicated to this course. In worst case, he needs to restart his previous search, performed soon after the actual lecture, trying to find the information he already had, again.

Hence, the typical scenario where our concept and future system applies to, is a learner, who kept in mind he read the desired information somewhere, but does not remember where exactly. The system is meant to serve as assistance to find an exact information as easy and quickly as possible, while additionally showing correlations and context that the learner might not have been explicitly aware of before, as well as allowing comments, structuring the repository. Furthermore, the system is trying to assist in composing the big picture and support skimming through collected information, which is not satisfactorily supported by now. Put another way, the system is trying to build a personal learning space including all objects related to the learner and the qualification he is trying to attain.

Of course, the promotion of a personal learning space immediately suggests personal learning environments (PLEs). By general definition, a PLE is a system helping learners to control and manage their own learning: "A PLE is a single user's e-learning system that provides access to a variety of learning resources, and that may provide access to learners and teachers who use other PLEs and/or VLEs [Virtual Learning Environments]." [3] Mostly, these systems have their origins in the demand for learner-centred approaches. Using a classification developed by Schaffert and Hilzensauer [4], the system proposed in this paper can also be classified as PLE. However, PLEs, generally spoken, often focus on examining and actively controlling the learning process and progress, which is particularly not the main objective of our system.

2 System Components

This section describes the system and its three core components in more detail. By now, the system has not been realized in full depth and detail, for this reason descriptions need to be understood as conceptual sketches.

The foundation of our system are *learning objects*. Basically, a learning object is any possible physical representation of information, such as locally saved files in different formats or an online web page. These learning objects are assembled and traditionally stored in a database by the *collection component*. Subsequently, the *preparation component* processes the assembled objects and extracts or assigns additional information. The interface enabling user interaction and offering the service as a whole to the user is formed by the *presentation component*.

In summary, the system realization is ought to adopt familiar Web2.0-paradigms such as a rich and user friendly interface and tagging in order to facilitate intensive usage. Additionally, the system is meant to smoothly operate in the background for most of the time by default; variations, adjustments and a more intensive usage are of course fostered for active users.

Collection Component. As basic component, the collection component is constructing an appropriate index. In order to entirely build the personal learning space, the collector needs to consider local as well as web content to be included into the index. As core feature, this component is not just extracting and processing textual information explicitly stored in *learning objects*, but handling three different index levels. The three index levels themselves are loosely connected and organised in two tiers.

The main index level *learning material*, constitutes the first tier and includes all learning content. Basically, this level is similar to known indexing components. Text-based content is processed according to traditional full text indexing mechanisms and an appropriate index is built. Hence, problems, approaches, and solutions of related areas, such as XML Retrieval described by Kamps et al. [5], are considered when implementing this level. Processing multimedia content is also desired and necessary, but not further specified at this time. Primarily, this level is employed to abstract from references to learning objects and substitute these references with file-independent references to nodes in this index level, since the technical granularity of *learning objects* is more or less arbitrary.

The second tier is composed of the two supplementary index levels *learning context* and *references*. The level *learning context* includes the context, as for example the subject, of a particular node in the main level learning material. Additionally, an independent classification of learning material can be stored in the third index level *references*.

As a result, the design of the collection component is closely related to issues of faceted search, as for instance examined by Henrich and Eckstein [6]. Using not only one, but three index levels—organised in two tiers—fosters personalization and learning insights by means of allowing an individual structure. Technically spoken this component uses a well-defined mix of existing technologies and frameworks, like Hibernate, Lucene, and Spring.

Preparation Component. Building upon the collection component, the preparation component uses the three different index levels of the previous stage, for a reasoning mechanism, adopting spreading activation techniques, such as described by Crestani [7]. Since every information in the levels of the second tier is connected to a particular node in the first tier, spreading activation models and theories can be employed to detect possible connections between single nodes of learning material. That way learning material not explicitly searched, however considered relevant, can be recommended to the user.

Presentation Component. Primarily, the presentation component offers the investigation interface to the user. Basic searching functionality like keyword search constitutes the foundation of the search element. Additionally, implementing an advanced search, the three index levels can be used as filters to narrow the search down by certain criteria. Principles of exploratory search, as for example described by Marchionini [8] need to be applied in order to satisfy traditional search activities like fact retrieval but in particular the search activities *learn* and *investigate*. Moreover, different visualisation components ought to be embedded into the search interface for additional presentation of various aspects. Search results can be visualised by tag clouds for textual information. The collection of learning objects can—based on a particular search or not—be visualised using associations of different levels, allowing browsing the repository on a visual level.

3 Work in Progress and Conclusion

In our opinion, the use and integration of a system as described, will soften the difficulties and challenges learners have to face due to the nature of modern learning. The overall effect needs to be carefully examined in subsequent user studies after the implementation is finished. At present, the collection component is designed in detail and implemented.

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Student Engagement with Peer Assessment: A Review of Pedagogical Design and Technologies

Karen Stepanyan, Richard Mather, Hamilton Jones, and Carlo Lusuardi

School of Computer and Advanced Technologies, Faculty of Enterprise and Innovation,
Buckinghamshire New University,
Queen Alexandra Road, High Wycombe, HP11 2JZ, United Kingdom
{Karen.Stepanyan,Richard.Mather,C.Hamilton-Jones,
Carlo.Lusuardi}@bucks.ac.uk

Abstract. The paper summarizes participatory action research that explores student attitudes towards a peer assessment exercise and further reveals a distinctive pattern in student responses. A formative and reciprocal peer assessment exercise was studied to identify possible reasons for low levels of student participation. The target group included students in an undergraduate course in computing. A follow-up questionnaire, undertaken by 36 students, was analyzed and compared against assignment marks. Finally, the access statistics of the virtual learning environment (VLE) were examined. The major results indicate the following: [i] an expectation of more explanatory and supportive tutor intervention; [ii] a student preference towards anonymity; [iii] student interest in accessing peer work; and [iv] that the allocation of marks and in-class activities factors are important in encouraging student involvement.

Keywords: Peer Assessment, Peer Evaluation, Student Engagement, Formative Assessment, Educational Technologies.

1 Introduction

Peer assessment is widely recognized to be the formative feedback and summative grading of individuals by peers of similar status [1]. Introduced as an innovative form of assessment, peer assessment aims at enhancing learning experience, assisting deep learning and enhancing the acquisition of critical thinking skills [2, 3]. Similarly to peer review process, used for evaluating work quality in professional occupations [4, 5], peer assessment encourages students to develop skills for the analysis and critical evaluation [6, 7].

This paper considers a case study built around a peer assessment exercise for assessing group work by undergraduate students. It aims to reveal potential vulnerabilities of methods and technical tools used for organizing and implementing web based peer assessment activities. Results from the study are interpreted to suggest measures for enhancing student engagement and the effectiveness of peer assessment.

M. Spaniol et al. (Eds.): ICWL 2009, LNCS 5686, pp. 367–375, 2009.

2 Theoretical Background

A review of the literature indicates great variation in the models of peer assessment used in higher education. While originally used in writing courses [8], studies on peer assessment now span many subject areas.

Topping's review and typology of peer-assessment [9], records 17 models classified according to variations in characteristics such as outputs, privacy, official weight (summative contribution), participant ability. Topping also highlights the importance of considering anonymity when designing peer assessment exercises.

Earlier studies suggest that peer assessment may encourage students to engage in cognitively demanding activities. Examples include comparing, clarifying, contrasting, diagnosing, considering deviations and summarizing information. These activities are believed to reinforce knowledge and lead to better understanding and deeper learning [10]. Additionally, peer assessment supports development of teamwork and communication skills [11], and improves the understanding of institutional assessment processes [12].

3 Case Study

The study summarized in this paper is based on year-long modules concerning the development of database applications. The modules were offered to second year undergraduate B.Sc. and Fd.Sc. students in computing.

The peer assessment exercise was introduced as an optional part of a required and graded group assignment, for which 20% of the overall module marks were available. The assignment required students to work collaboratively in pairs, to design and develop a database. A written report was then submitted for marking. As part of the peer assessment exercise, students were asked to post specific sections of their reports for assessment by colleagues.

The typology of this exercise [13] could be expressed as being one of a formative, out of class, mutual, distance, not graded, voluntary, cross-ability and group peer assessment. The main incentive for student participation was an opportunity to improve work (consequently, grades) on the basis of suggestions made by their peers.

The peer assessment exercise was delivered in asynchronous mode using a discussion board on a Blackboard™ virtual learning environment. Each discussion board thread comprised the original report and the peer-reviews for each report.

The peer assessment exercise consisted of two tasks: [a] posting their group-work on the VLE; and [b] posting constructive feedback on the work of other groups. Students were allowed two weeks for completing the task. The exercise was thoroughly explained and tutor support was made available to the students throughout the peer assessment period. Blackboard announcements were posted and email reminders sent to all the participants to notify them of approaching deadlines.

Only four students in two groups completed the first peer-review task. Although posts were of high quality, the low level of participation was of some concern. Participant attitudes and behaviour were therefore investigated further with respect to: [a] critical reflection; [b] extent of passive (lurking) and active participation; and [c] by extending the study in an attempt to understand attitudes towards specific components of the peer assessment exercise.

4 Research Aims and Analysis

This investigation aims to understand attitude, behavioural, teaching and technical factors that may influence levels of student participation in peer-review exercises. Towards this end the afore-mentioned peer-assessment case study is assessed with reference to VLE log metrics and a 21-item questionnaire returned by 36 respondents.

The demographics of respondents are summarized in Table 1.

Table 1. Participant demographics

	Category	*Frequency*	*Percent*
Age	*19-20*	8	22.2%
	21-22	15	41.7%
	Over 23	12	33.3%
	Not Spec	1	2.8%
Sex	*Female*	8	22.2%
	Male	27	75.0%
	Not Spec	1	2.8%
Total	-	36	100%

4.1 Analysis of the Blackboard™ Access Records

In addition to active participation, log entries also contain records of passive presence (lurking) around the discussion, assessment and announcement areas established to support the peer-review process. Logs record 168 ‘views’ of posted materials by 18 students (50% of the cohort) accessing exhibited work and feedback. Log statistics therefore suggest: [a] a high level of interest amongst ‘passive’ participants in work submitted by colleagues; and [b] that passive “non-posting” involvement was much more widespread than active participation.

Despite seemingly low interest in initially posting contributions, the logs show that the peer assessment area continued to be accessed by students some time after the end of the exercise. Some 20% of all ‘hits’ recorded occurred up to two months following peer assessments with a further 6% logged during a 10 day period before students were to site a ‘time-constrained assessment’ (a formal test). Because this examination included problems similar to those given during the peer-assessment exercise, it seems very likely that students visited the peer assessment area for revision purposes.

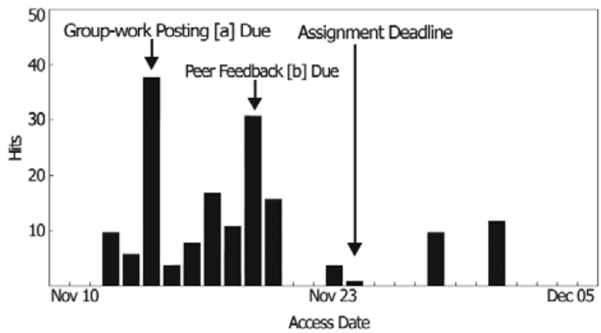

Fig. 1. Access to peer assessment area on Blackboard™ with deadlines indicated

Results indicate that many students who did not actively participate did in fact ‘passively’ view content. A further cycle of study was undertaken to investigate possible reasons for low levels of active involvement, thereby suggest how greater participation in peer assessment work might be encouraged.

4.2 Student Feedback on Peer Assessment

A 21-item questionnaire was issued to determine student opinion concerning: [a] the rationale for peer assessment; [b] the design and delivery of the exercise; [c] levels of comfort/acceptance associated with elements of the peer assessment process; and [d] web technologies used for the exercise.

The great majority of students indicated that the exercise was fairly well explained and presented (86% or responses were recorded for categories of “satisfactory” and “very clear”). Additionally, results indicated that 67% of all respondents were interested in being able to view the work of their peers; this observation is also consistent with behaviour recorded in access logs. A greater proportion (78%) believed that the exercise could be beneficial. The proportion of those considering the exercise to be of no benefit (22%) was great enough to be of concern to the teaching team. While most students were interested in accessing their peer’s submissions, only 50% were interested in providing feedback to their classmates.

The discovery that students were more inclined (78%) to engage if marks were awarded for participation is consistent with earlier studies [10]. A significant proportion (22%) suggested that one principal area of improvement would be to reward the quality/level of participation in peer assessments through summative grading.

The timing of the exercise was another factor shown to be important for increasing levels of participation. Two thirds of respondents indicated that timing would affect their level of engagement in peer assessments. Many preferred to conduct peer-reviews in-class rather than off-site and three students (8%) were particularly emphatic on this point (see Figure 2.).

Earlier research suggests that less desirable effects of peer-assessments may include increased participant workloads and anxiety levels [9]. The assessment of

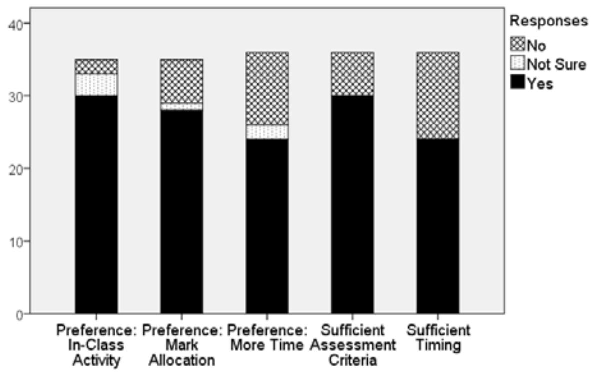

Fig. 2. Preferences in peer assessment exercise format

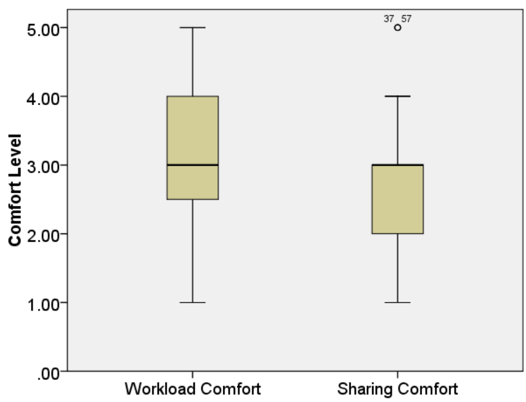

Fig. 3. Comfort level of students with [a] added workload and [b] required sharing of work (1: least; 5:most comfortable). Note: box plots are paired here for convenience of presentation only. Lickert scales for the two boxplot distributions should not be compared because they are nominal and represent different but (statistically) interdependent 'comfort' metrics.

student 'comfort' level with regards to anonymity and workload revealed that 43% of participants were "very/uncomfortable" to post their work publicly. Students felt relatively more comfortable in terms of workload: 74.2% (mean=3.09, std. dev.= 0.951, n=35) of respondents indicated workload to be from "moderate" to "insignificant" (Figure 3). However, only 8.3% indicated insignificant increase in their workload, showing the demanding nature of the exercise.

For the purposes of triangulating/confirming the results reported above, students were also asked to express which improvement they believed might have the greatest "participation encouraging" impact in peer assessment exercises. Results (see Table 1.) indicate that allocation of marks (22%) and clearer justification for exercises with

Table 2. Student perceptions of the most important factors for encouraging participation in peer assessment

Student Suggestions	*Freq.*	*%*
Clear explanation and justification of peer assessment	*2*	*5.6*
Clear explanation and more support	*5*	*13.9*
Active participation of others	*2*	*5.6*
Allocation of Marks	*8*	*22.2*
In-Class Activity	*4*	*11.0*
More Time Allocation	*2*	*5.6*
No Suggestions Made	*13*	*36.1*
Total	***36***	***100***

provision of further support in completing reviews (together 20%) were the most important factors in influencing engagement with peer assessment. There was also notable support (11%) for delivering peer assessment exercises in-class.

Comments on the Web tool. The VLE and discussion board in particular, were central in facilitating the peer assessment. A Blackboard™ environment that contained an announcement, resource and communication area, was made available for the purpose of the exercise. Discussion board threads were created for posted work and peer feedback.

VLE access records were notably consistent with questionnaire data; both sources indicated that 56% of all participants accessed the peer assessment area. Most of those who used the system (91%) rated access as being 'very' to 'moderately' easy. However, because 44% of participants did not visit the VLE, this observation cannot be extrapolated to the remainder of the cohort.

4.3 Correlation Analysis of Survey Data against Student Marks

Student marks for the first two module assignments were averaged and were then analyzed alongside questionnaire data. The intention of analysis was to reveal patterns between responses and mark performance. For example it was of interest to know if higher achievers were more likely to appreciate the benefits of peer assessment or more willing to provide feedback. Due to the non-parametric nature of the data Kendall's tau statistic was used for calculating correlation coefficients (Table 3).

The results indicate that average marks (AM) and anticipated level of additional workload (ALAW) associated with peer assessment are significantly correlated (r=-.335). The direction of this relationship suggests that higher achieving students are more likely to report lower level of expected extra workload as a result of undertaking peer assessment. The statistically significant correlation (r=.334) between student average marks (AM) and willingness to access peers work (WAPW) suggests that higher achieving students are also more likely to be interested to see the work of their peers. While some practitioners may expect that lower achievers would be most interested in work of others, the results suggest the opposite.

Table 3. Bivariate Non-parametric Correlation (Kendall's tau) of Collected Questionnaire Data and Student Marks

Kendall's tau_b		*CI*	*AU*	*ALAW*	*WTF*	*WAPW*	*AM*
CI (Clarity of Introduction)	Cor. Coeff.	1					
	Sig. (2-tailed)	.					
	N	36					
AU (Anticipated Usefulness)	Cor. Coeff.	0.205	1				
	Sig. (2-tailed)	0.154	.				
	N	36	36				
ALAW (Anticipated Level of Additional Workload)	Cor. Coeff.	-.431**	0.038	1			
	Sig. (2-tailed)	0.003	0.795	.			
	N	35	35	35			
WTF (Willingness to Receive Feedback)	Cor. Coeff.	-0.025	0.13	0.187	1		
	Sig. (2-tailed)	0.876	0.408	0.246	.		
	N	35	35	34	35		
WAPW (Willingness to Access Peers Work	Cor. Coeff.	0.252	0.071	0.18	.356*	1	
	Sig. (2-tailed)	0.112	0.649	0.257	0.041	.	
	N	35	35	35	34	35	
AM (Average Mark TCA&CW1)	Cor. Coeff.	0.076	-0.002	-.335*	0.181	.334*	1
	Sig. (2-tailed)	0.572	0.987	0.014	0.219	0.024	.
	N	34	34	33	33	33	34

Notes: [1] ** = Correlation is significant at the 0.01 level (2-tailed).
[2] * = Correlation is significant at the 0.05 level (2-tailed).
[3] CI, AU and ALAW are likert scale, and WTF and WAPW are dichotomous (y/n) data.

Another, less surprising result, indicates a highly significant correlation (r=-.431) between anticipated level of additional workload (ALAW) and the clarity of introducing (CI) the peer assessment exercise. The results suggest that students are more likely to record lower level of anticipated workload when clarity of introduction is reported to be greater. No other statistically significant correlation was discovered. As in any correlation analysis these findings do not imply causality. Yet, these results may guide practitioners when facilitating such exercises.

5 Use of VLE for Peer Assessment

The VLE used in this study had no dedicated facility for peer assessment. Group management and discussion boards can be used as an alternative, but they impose certain limitations. A group management facility provides closed communication tools, such as chat, forum and group emailing. These tools can be used for collaboratively completing tasks before submitting them for peer assessment. However, the issues identified in the questionnaire show that alternative technologies, for example discussion boards, may lack certain desirable features. Such features include those that ensure confidentiality but allow facilitators to identify individuals participating in assessments. However, the use of such additional tools may discourage participation since these will involve familiarization and increased exercise workloads. Thus, any perceived benefits should be carefully balanced against the additional learning burden of adopting new technologies.

6 Conclusion

The results suggest that students, in one way or another, were largely positive about the peer assessment process. However, some critical issues that deserve the attention of practitioners and researchers were identified. These included that: [i] students may not initially perceive the rationale for and potential benefits of peer assessment. Nevertheless, average marks were not found to be correlated with perceptions of 'anticipated usefulness' of peer assessment; [ii] student marks were significantly correlated (r=-.335) with anticipated levels of increased workload, suggesting that peer assessment activities must be designed to meet the needs of all students; [iii] from the questionnaire study it was apparent that participants were very interested in the solutions submitted by their colleagues. Correlation analysis suggested that those achieving highest marks were most interested in studying the solutions of their colleagues (r=.334). The results of the VLE access statistics are consistent with this finding and indicated that solutions posted were viewed long after the peer assessment exercise had been completed, possibly for purposes of revision; [iv] many students are not completely comfortable with posting work publicly, often preferring to remain anonymous when making their own submissions and when assessing peers; and [v] questionnaire results suggest that grading and in-class work are the very important factors for encouraging participation.

Overall, findings strongly suggest that design, delivery techniques, facilitation methods and specific features of technology (for example, those that allow a degree of anonymity) are important factors for creating 'safe' learning areas that encourage greater participation in peer-assessment exercises.

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Constructing the 2D Adventure Game-Based Assessment System

Jing-Yao Tang[1], Jui-Hung Chen[1], David Tawei Ku[2], Louis R. Chao[1], Timothy K. Shih[3], and Martin M. Weng[1]

[1] Department of Computer Science and Information Engineering, Tamkang University, Taipei, Taiwan, R.O.C.
U8190124@gmail.com
[2] Department of Educational Technology, Tamkang University, Taipei, Taiwan, R.O.C.
dtk@mail.tku.edu.tw
[3] Department of Computer Science, National Taipei University of Education, Taipei, Taiwan, R.O.C.
timothykshih@gmail.com

Abstract. Due to the advanced computer and network technologies, it could be helpful to conduct an advanced distance learning system for learners to process their learning activities in anytime and anywhere. However, according to many research issues which found that the learning motivation is the most important element to encourage people into their learning and assessment activities. In this paper, we proposed the 2D Adventure Game-Based Assessment System which not only could draw people into their learning activities, but could help instructors easily to design and manage the related learning and assessment content.

Keywords: GBL, Assessment system, Game design, Learning Motivation.

1 Introduction

In recently year, there are more and more advanced computer hardware and communication technologies could help us to process a lot of difficult problems in many domains, even though in education domain. Due to the advanced e-learning methodologies and related auxiliary computer technologies, there are more and more researchers have interested in observing some key elements of "Learning Motivation Encouraging". How to promote such advanced e-learning system and to attract people to use them will become more and more important. Marc Prensky mentioned that general knowledge concepts and learning abilities could be improved by game play behavior [1]. It is practical to integrate interactive game elements into learning activities to improve the learners' efficiency, performance and motivation of learning [2]. Instructors could utilize the game-based learning tool easily to develop the interactive game-based learning environment in order to let learners' to enjoy their immersion experience learning behavior [3]. Kuang-Cheng Feng point out that we could develop

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one on one game-based learning environment by monitoring the learner's learning portfolio [4]. Ang Chee Siang indicated that we could integrated the behavior, cognitive and motivation factors into the course mission in order to improve the learners' learning motivation and learning performance [5]. Magy Seif El-Nasrpointed out that learner could utilize the simulation game to develop their abilities on problem solving, information searching and analysis [6]. They also could make practice on their learned skills in this game environment. Some issues had point out the relations between game playing behavior and game playing motivation [7][8] which provide the Model in order to analysis the game playing preferences. It could helpful for providing the hint to analysis and to design the learner's learning motivation analysis methodology. According to above discussions, we found that game playing behavior and related game elements could effectively improve the learners' learning efficiency and motivation. In this paper, we would like to propose the 2D Adventure Game-Based Assessment System and related course content authoring tool. By using assessment system, learners could do the assessment activities as game mission solving. When they finished all particular game missions, they could get some rewards to attract them and to help them to do the next assessment stage. Instructors could easily to edit the assessment content and easily to realize learners' assessment status. The remaining of this paper is organized as follow: In Section 2, we will illustrate the architecture of our proposed 2D Adventure Game-Based Assessment System, related system modules and workflow. In Section 3, we will introduce the sample demo of the Game-Based Assessment System. Finally, the conclusion and the future work are shown in Section 4.

2 2D Adventure Game-Based Assessment System Architecture

In this section, we would like to introduce the architecture of this 2D Adventure Game-Based Assessment System and its workflow.

2.1 2D Adventure Game-Based Assessment System Workflow

Fig 1 shows the 2D Adventure Game-Based Assessment System architecture. The system includes three sub systems. There are 2D Game-Based Assessment Content Authoring System, 2D Game-Based Assessment Environment Management System and Game Playing System. Instructor could utilize the 2D Game-Based Assessment Content Authoring System to manage their assessment activity and related content editing. The 2D Game-Based Assessment Environment Management System has focused on managing the related data processing when Instructors/learners work on their content editing/assessment activities. Game Playing System will take charge of presenting the game assessment content learners.

Fig.2 shows the game playing workflow of the 2D Adventure Game-Based Assessment System and Content Authoring Workflow. In 2D Adventure Game-Based Assessment System part, the learner needs to check the authorization first. When the learner login successfully, the system will load user assessment portfolio and try to

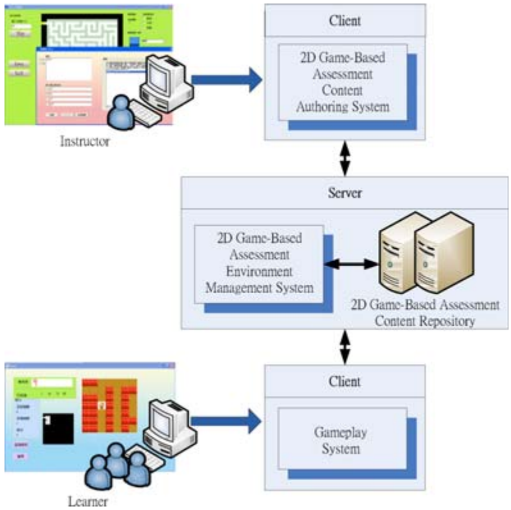

Fig. 1. 2D Adventure G ame-Based Assessment System Architecture

initialize the related game playing status. Then the learner could select the related assessment mission they want to start. When the learner get start and try to solve the assessment mission, he/she could go to the related mission area according to the hint information which provide by NPC (Non-Player Character). The NPC will provide the related hint information to players. Therefore, the learner could finish the game mission as quickly as possible. When the learner finish all missions, the game system will save the learner's process of play and assessment status in his/her assessment portfolio and send the portfolio back to the backend server. In Assessment Content Authoring Workflow part, the first step for the instructor is to login and check the authorization. Then the instructor could start to work on the game-based assessment content editing. In this editing phase, the instructor need to design two types of content. The first is the interactive assessment content by option selecting. The instructor could easily to utilize our proposed assessment content authoring interface and related guilder to design the assessment content in option select mode. The instructor could utilize the existing media content (Like the Flash, various kinds of video media… etc) which made by other people over the internet in order to edit the assessment content. The second is to fit these related assessment content in 2D adventure game map. The instructor could select the random map which provide by authoring tool in order to design the game mission. Then the instructor could select the map, to decide the mission point, to design the related materials (Like NPC, Game events) and to setup related rewards when designing the game mission scenario. At last, the instructor could save all contents in one integrated package and upload it to the backend content repository in order to share it to other instructors.

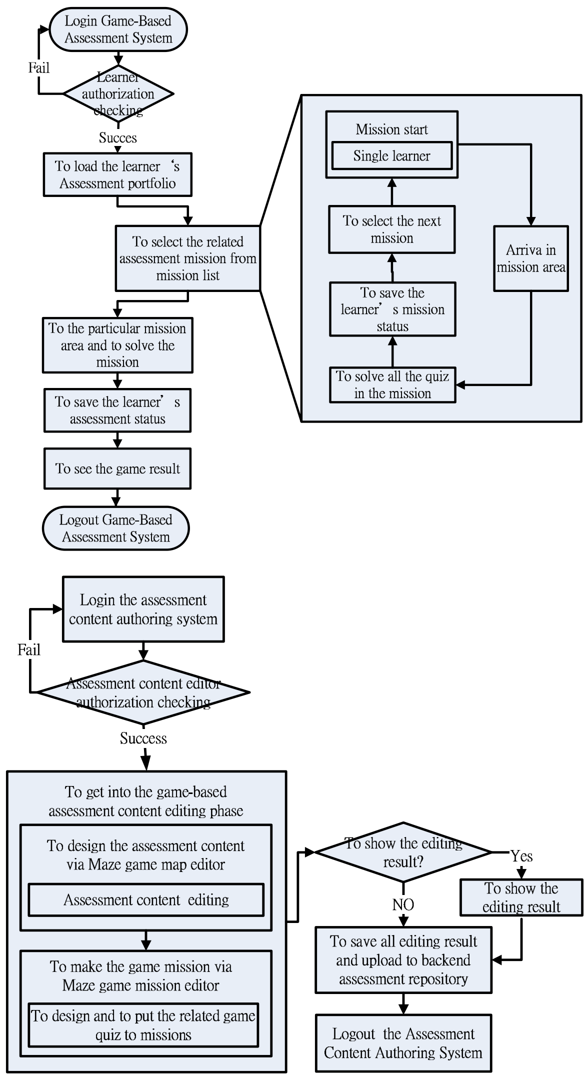

Fig. 2. 2D Adventure Game-Based Assessment System and Content Authoring Workflow

2.2 2D Adventure Game-Based Assessment System Modules

In this section, we will introduce the related system modules which show in Fig 3. The descriptions about the 2D game-Based Assessment Content Authoring System modules which as follows:

- Game assessment content package repository connection processing module: It will take charge of the data connection from backend server to user client.
- Maze game assessment content editing module: It's responsible for provide the adaptive content editing interface and related guilder to instructors in order to reduce the loading when doing content editing.

- Maze game assessment content package combined module: It will take charge of the format checking and data compressing. All data will be integrated in one zip package.
- Video/Quiz assessment content editing module: It' responsible for managing and providing the interactive game puzzle in option selecting and game hint information in video present style.
- Maze map editing module: It will take charge of the related materials and initial parameters in 2D adventure game map.
- Game assessment rule editing module: It will take charge of the whole game assessment rules definition. The instructor could utilize the module easily to design the related assessment rules and put these rules to the game map.

The Game Playing System which includes the Game assessment content package repository connection processing module, Maze game assessment content package processing module, Video/Quiz assessment content processing module, Maze map processing module and Game assessment result processing module. The functionalities will similar to the previous modules we mentioned, but they only take charge of related data processing and send the assessment result to the game assessment management server.

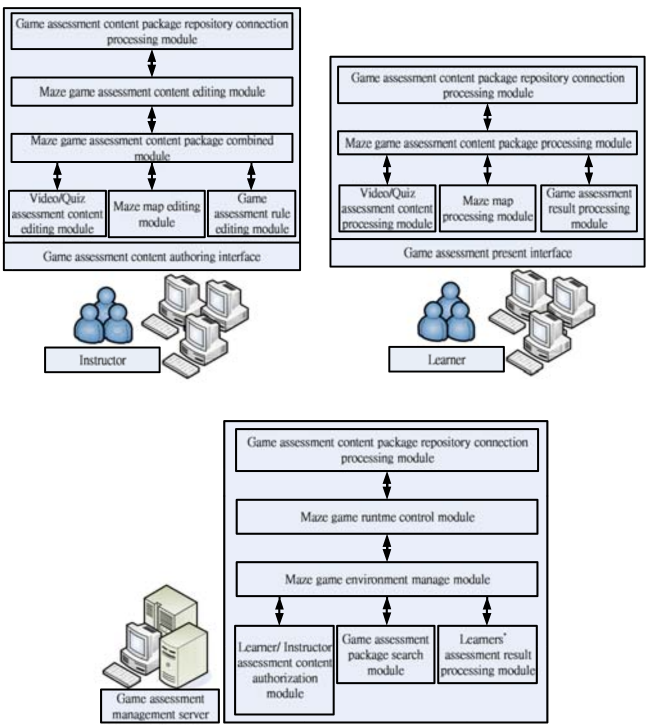

Fig. 3. 2D Adventure Game-Based Assessment System Modules

The descriptions about the 2D Game-Based Assessment Environment Management System modules which as follows:

- Game assessment content package repository connection processing module: It will take charge of the data connection from backend server to user client.
- Maze game assessment content present module: It responsible for managing the game runtime and data processing in order to make the server loading in stable status.
- Maze game environment manage module: It will take charge of managing require which provide by learner/instructor client. Like the user authorization, assessment content searching and assessment result managing.
- Learners/Instructor assessment content authorization module: It responsible for managing the user authorization and registration.
- Game assessment package search module: It will take charge of managing the materials searching require from instructor.
- Learners' assessment result processing module: It' responsible for managing and processing the learners' assessment result.

2.3 2D Adventure Game-Based Assessment System – Learning Assessment and Motivation Analysis

In learning assessment part, we could utilize the two-way specification table to record the assessment content not only in real assessment score but in knowledge inclination. The two-way specification table is proposed by Anderson and Krathwohl [9].

This table has two dimensions. One is for knowledge dimension, and the other is for cognitive process dimension. The knowledge dimension indicates the knowledge classification which includes the factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge. The cognitive process dimension includes remembering, understanding, applying, analyzing, evaluating and creating.

Table 1. The Two-way specification table

Cognitive process dimension / Knowledge dimension		Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	The suggestion amount of questions	The practical amount of questions
Game Mission	Factual knowledge								
	Conceptual knowledge								
	Procedural knowledge								
	Meta-cognitive knowledge								
The suggestion amount of questions									
The practical amount of questions									

Knowledge dimension classifies the learning knowledge classifying from the "Learning" perspective. The cognitive process dimension classifies the learner's thinking model from the "Thinking" perspective. The two-way specification table is summarized in Table 1. In learning motivation checking part, we would like to utilize the Need-hierarchy theory which proposed by Maslow [10] to cooperate with Two-way specification table to analysis which Learning Motivation Layer does the learner stay. The Learning Motivation Layer will mapping with several particular elements of Cognitive Process Dimension from Two-way specification table. When designing the Two-way specification table, the instructor will select the related elements of Cognitive Process Dimension, it will automatically do the elements mapping to the particular Learning Motivation Layer and it will add one score on the layer. When score with the layer is achieving to the Total Score. The learner's learning motivation could automatically get into the next Learning Motivation Layer and the system could provide related rewards and help information to encourage him/her to do the next learning assessment stage. Learner's learning assessment result could clearly to show up as graphic chart to the instructor in order to let him/her easily to know the learner's assessment status in time. At last, the instructor could reference the result and to adjust the assessment content, activities or principles of teaching.

Table 2. The Learning Motivation Analysis Table

Learning Motivation Layer	Score	Total Score	Knowledge Level	Cognitive Process Dimension	The Goal of Learning Motivation Layer
Physiology			Basic Knowledge	Remembering Understanding	To practice and to learn the Basic Knowledge
Safety			Basic Advanced Knowledge	Understanding Applying	To practice and to organize the Basic Knowledge into the Advanced Knowledge
Belonging			Normal Advanced Knowledge	Applying Analyzing	To practice and to learn the Advanced Knowledge by Team Collaborating
Esteem			Particularly Advanced Knowledge	Analyzing Evaluating	To practice and to focus on learning the particularly advanced knowledge
Self-Actualisation			Complete Knowledge	Evaluating Creating	Refine the knowledge and trying to challenge the knowledge

3 2D Adventure Game-Based Assessment System Demo

In this section, we would like to show some result of our proposed system. Fig 4 shows the part of assessment content editor functionalities of game map and related parameters. When instructor starts to edit the game assessment content, he/she could select the map present style. Then the instructor could define the difficulty level in the

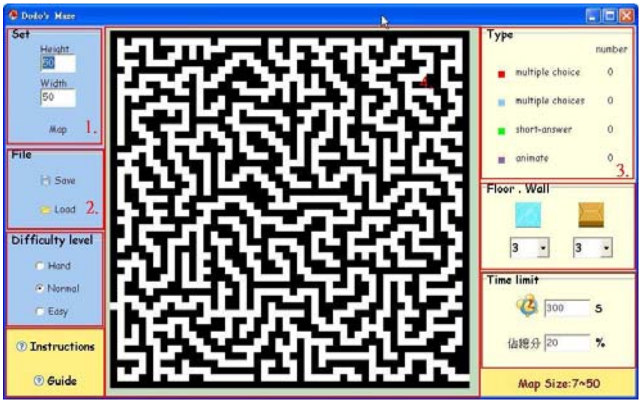

Fig. 4. 2D Adventure Game-Based Assessment System - Game Map Editor

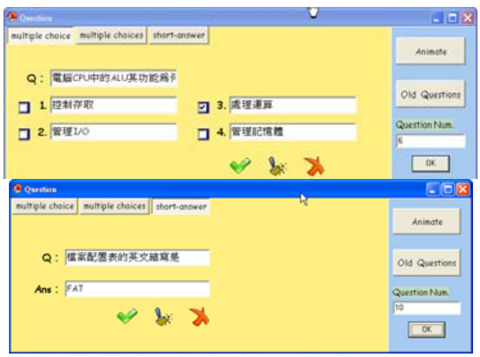

Fig. 5. 2D Adventure Game-Based Assessment System - Assessment Content Editor

game. We provide three difficulty levels, there are simple, normal and difficult. The difficulty level could effects the visible view which player could see. When finished the setting of map parameters, the instructor could keep continuing on editing the game map. During game map editing phase, the instructor could select the point (Scores) in game map in order to design the NPC/game event. Then, the instructor could fit the related assessment content by using option style which form game assessment repository or he/she could design new assessment content by using authoring tool which show in Fig.5. When the instructor finished whole game assessment content, he/she could save the content in one zip package and upload it to the backend repository.

When the instructor finished the game assessment content editing behavior, the learner could download the related assessment content and start to do his/her game playing assessment activities. Fig.6(1) shows some demo screen dump of game playing environment. The learner has to solve all missions in the maze. Player will keep continuing to find the useful hint and related information which form the NPC

Fig. 6(1). 2D Adventure Game-Based Assessment System - Adventure Game Environment

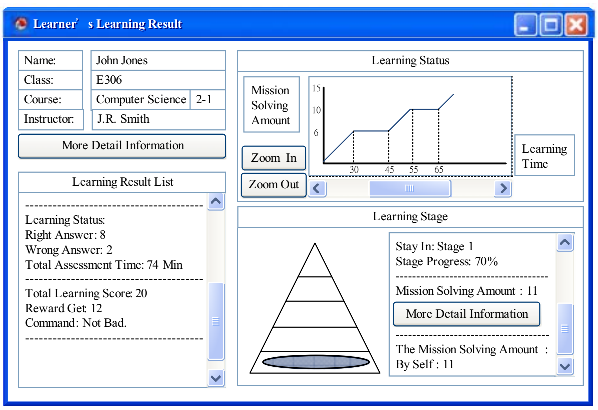

Fig. 6(2). 2D Adventure Game-Based Assessment System - Assessment Result Form

and try to solve the related events during the game. When he/she solves all missions, the assessment results will send back to the backend game assessment management system. The learner could see his/her assessment results in learners' assessment result list as Fig 6(2).

4 Conclusion

In this paper, we proposed the 2D Adventure Game-Based Assessment System and related content authoring tools. Instructors could easily to edit the related assessment content by user friendly interface. They also could easily to manage the learner's assessment status and motivation by graphic chart. Learners could enjoy the assessment activities in order to improve their learning efficiency and skill ability. In the next step, we will attempt to involve the IRT (Item Response Theory) and QTI standard in our system. It could not only provide the adaptive assessment environment, but could also make the assessment content more easily to share the assessment content to other instructor. Hopefully, it could help learners and to attract them to enjoy the game-based assessment environment when doing the knowledge training activities.

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Using the Social Web to Supplement Classical Learning

Stefan Trausan-Matu, Vlad Posea, Traian Rebedea, and Costin Chiru

"Politehnica" University of Bucharest, Department of Computer Science and Engineering, 313 Splaiul Independentei, Bucharest, Romania
{stefan.trausan,vlad.posea,traian.rebedea, costin.chiru}@cs.pub.ro

Abstract. The paper describes a complex e-learning experiment that has involved over 700 students that attended the Human-Computer Interaction course at the "Politehnica" University of Bucharest during the last 4 years. The experiment consisted in using social web technologies like blogs and chat conferences to engage students in collaborative learning. The paper presents the learning scenario, the problems encountered and the tools developed for solving these problems and assisting tutors in evaluating the activity of the students. The results of the experiment and of using the blog and chat analysis tools are also covered. Moreover, we show the benefits of using such a scenario for the learning community formed by the students that attended this course in order to supplement the classical teaching and learning paradigm.

Keywords: Social Web, E-learning, Evaluation, CSCL, Blog, Chat.

1 Introduction

The Social Web [1] (or Web 2.0) provides complex applications that allow people to create and share content, to discuss, and group themselves into communities. A natural use of these affordances is Computer Supported Collaborative Learning (CSCL, [2]), which is based on the socio-cultural ideas introduced by Vygotsky [3], stating that knowledge is socially constructed.

This paper presents a series of CSCL experiments that took place at the "Politehnica" University of Bucharest in a course on Human-Computer Interaction (HCI) for the Computer Science and Engineering students. For 4 years in a row (2005-2008), several assignments were given to students in order to establish a medium sized knowledge building community using Social Web instruments. In the first two years students had up to three assignments to be performed in small groups using instant messenger (chat) conferencing [4]. In the last two years, the range of experiments was extended to blogs and social networking. In addition, the students used discussion forums for interactions with their peers and their tutors.

In the next section, the paper introduces the CSCL concepts that constitute the theoretical basis for the experiment, plus the learning scenario. Then the key findings and results are presented. Finally, we present our conclusions and plans for further development.

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2 The Learning Scenario

The HCI course where the experiments were performed is available for students in their senior year of undergraduate studies. Numerous students enroll for this course, in fact there were 160 students in the 2007-2008 academic year and 324 students in the 2008-2009 one. During the course, students were taught the theory of interface design and evaluation and they had to apply their theoretical knowledge to practice by individually developing several Web 2.0 applications for the laboratory.

In order to improve the learning process by using CSCL, we designed the following scenario based on CSCL ideas [2]: The students were divided in groups of four. They were asked to construct a web site for their team using the technologies and the theoretical principles learnt in the course. They were also asked to use a blog to share their personal experiences with the technology and to discuss about the new and interesting materials they discovered during this course. Eventually, the students were also required to use chat for debates on several themes specified by the teacher. One of the main ideas of our new learning scenario was that students can understand better how to design and implement Web 2.0 interaction techniques if they are also intensively using them for group knowledge building.

For the social building of knowledge in small groups using instant messenger chat conferencing, students had a number of assignments ranging from 1 to 3. For each one, they were supposed to individually study collaborative technologies and, afterwards, to debate in chat sessions in groups ranging from 3 to 8. In the first part of the conversation, each student had to champion one of these technologies by presenting its features and advantages and criticize the others by invoking their flaws and drawbacks. In the final part of the chat, they had to discuss on how they could integrate all these technologies in a single online collaboration platform. Therefore, in a single conversation the students first engaged into a debate whose results are then used for collaboratively building a solution to a given problem. The ConcertChat environment [5] was used due to its features, such as the use of explicit references and of a whiteboard and because it saved the chat consistently conversations on the server. These chat logs can be viewed and replayed, and they were then used by the tutors to evaluate the results of the chat conversations.

3 Results

We consider that the most important result from these experiments is the actual collaborative knowledge constructed by these groups of students. The resulted content and the connections that were created between students are very valuable for many reasons – documenting new technologies and less known problems among them, as well as creating bonds between students and pinning down actual knowledge.

We analyzed the types of content created in order to establish their actual value for the community and we also tried to evaluate which was the actual educational gain for the individual student from this exercise.

We had 45 blogging teams in 2007-2008 and 96 in 2008-2009. These teams produced over 700 posts in the first year and 2200 in the second one. This content was

Table 1. Distribution of posts according to their categories

Percentage of posts in each category	Personal Experiences	New Technologies	Studied Technologies
2008 (%)	23	43	34
2009 (%)	14	21	61

not always of top quality and it was not always useful therefore we needed to define some criteria for interesting and useful posts and blogs.

We have classified the posts in 4 categories – personal experiences (bug solving, experience with a new API or with creating a small feature), technologies studied (descriptions or personal views on technologies studied during the course or in the lab), new technologies (also descriptions and/or views of new technologies usually based on documentation more than on personal experience), and miscellaneous (project's journal, news, social, fun, and other articles meant to attract visitors and develop some social interaction). The distribution of posts is presented in the following table and discussed further in this section.

We considered that the most useful were the ones that presented personal experiences because they are much more valuable from the point of view of the community and of the user. Another important category was the one of new technologies. These articles presented ideas or technologies that were connected to the contents of the course or of the lab but there was not enough time to study them. Such examples are Microsoft's Silverlight (http://silverlight.net) for implementing interfaces, FOAF (http://www.foaf-project.org/) for semantically describing networks of people, etc..

Furthermore, two systems were designed for chat analysis and they were used for supporting the tutors in the evaluation process during the 2008-2009 academic year. Preliminary results on a limited set of chat conversations will be presented at the CSCL 2009 conference [6]. The tutors used the data that the tools provided in order to have a better understanding of a chat conference in less time. For example, the implicit references, the threads and the list of important topics were used for enhancing the content-based analysis. The same may be argued in the case of the grades given by the Polyphony Analyzer system [4, 6] for each utterance in the chat based on their content and on speech act factors such as approval and disapproval. In addition, the total score of all the utterances issued by a participant is used to provide an automatic grading. By using these statistics as well as the visualization from Polyphony, the tutor can better evaluate the degree of involvement of each student in the chat. The preliminary tests were conducted on a group of 4 chat sessions involving teams of 4 members each that were analyzed separately by four tutors – two of them using the tools and the other two without any software assistance. The grading error for Polyphony is 10.1%, twice better than the second system, ASAP [7], and quite close to the error rates of the tutors. Nevertheless, the correlations between the average tutor grade and the grades provided by each of the two systems are significantly poorer compared to those of the tutors. Still, the correlation obtained by Polyphony is encouraging for a subset of three chats out of the four - .85, only slightly worse than the average tutor correlation. The improvement in time needed for the evaluation of a chat session is also hopeful as the time required for analysis was reduced by more than 30% for the tutors employing the analysis tools.

4 Conclusions

The work presented in this paper describes a complex learning experiment, involving collaborative software such as blogs and chats. The experiment has been used for several years and more than 700 students participated in it over this period of time. These students had the opportunity to learn interesting new facts by becoming integrated in a learning community and by creating knowledge artifacts for this community. The knowledge artifacts were used by the students in the same year and also, as some of the statistical results show, they had an influence over the students that followed the course in the next academic year.

The results show that this method of learning was appreciated by the students who worked hard and produced an important quantity of valuable content. Also, students' involvement in chat assignments was beyond our expectations. We suggested that a typical chat session would have last for about one hour; however, more often than not this duration was exceeded. Moreover, the students inter-animated in a high degree, examples of different such patterns being discussed in [4].

Finally we consider that this paper proves that we can use social software to supplement classical learning with good learning results and to provide a pleasant learning experience for the students.

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If a Student Takes Control: Facilitator's Tasks and Responsibilities

Terje Väljataga

Centre for Educational Technology, Tallinn University/Tampere University of Technology,
Narva road 25,
10120 Tallinn, Estonia
terje.valjataga@tlu.ee

Abstract. This paper presents initial research results of an intervention into higher educational teaching and studying practices from facilitators' point of view. The intervention was implemented into an international Master's level online course mediated by landscapes of social media tools and services. In this course more emphasis was put on a shift of control from a facilitator to a student or a group of students in the following aspects: setting up one's study goals, choosing activities, selecting appropriate resources, including technology and defining one's evaluation criteria. The initial analysis showed that the facilitators gained a lot in terms of understanding the benefits of exploiting social media tools and services for their teaching practices, perceiving a need of having a different role as well as the shortages and problems while being a facilitator in such a course.

Keywords: student control, social media, instructional design, facilitation strategy, self-directing intentional learning project, cross-cultural collaboration.

1 Introduction

Globalization and successively emerging technology are changing modern job scenarios significantly. Skills and knowledge that are required for work have not only increased dramatically but they are also changing constantly. We are regularly confronted with situations where we have to deal with rather complex and dynamically altering and often unexpected requirements [1]. Individuals are expected to have the ability to cope with quick changes and acquire new knowledge and skills whenever needed i.e. to be competent in self-directing one's intentional learning and change projects. Furthermore, as much of our activities are more and more technology mediated and take place in distributed work settings, successful actors need to make efficient and effective use of networked technologies [2].

Herewith, higher education must focus not only on supporting simple domain-dependent knowledge but more emphasis should be put on developing domain independent knowledge and skills. Educational experiences should prepare individuals for coping with problems outside of the boundaries of pre-structured and well supported formal educational settings [1]. Nevertheless, in reality higher education does not pay

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enough attention for supporting the advancement of aforementioned competencies. Bringing about changes into current teaching and studying practices in order to create challenging educational experiences for students one has to overcome a number of barriers and break away traditional way of teaching.

For example, facilitators have to move beyond the barriers of closed institutional learning (teaching) systems as being predefined and structured, and find alternative technology to support participants' activities. Open and easily accessible social media seems to be a promising option in this regard. Investigating social media tools and services for one's purposes offers also a significant potential for dealing with information and for supporting knowledge building individually and within groups [1].

In addition to technical obstacles traditional instructional design models have reached their limits for promoting the competence advancement in the area of self-directing one's intentional learning and change projects in a technologically mediated setting. These models emphasise on breaking a task down into manageable chunks, establishing objectives, and measuring performance based on those objectives [3], thus representing somewhat of a closed and linear system defined by an instructional designer. Although a student control to some extent and initiative is accepted and encouraged in some of these models the author of this paper thinks that there is not enough emphasis put on a student's ability to set up his goals, decide upon and carry out his tasks; search and select resources (claimed already by [4][5]) as well as technological landscape of tools and service, defining outcomes and evaluation criteria according to his own interests and preferences [6]. It is argued that students given control over their instruction might be more likely to think about what they are doing as a result of having to make choices along the way [7]. In consequence a different approach is required, which moves on in the direction of flexibility and student-empowerment in order to keep up with technological and societal changes [8].

Implementing an intervention, which focuses on increased student control and responsibility over one's study activities raises a question of what are the tasks and responsibilities of facilitators in this case. It is a frequent misconception that giving a student more control and responsibility of his/her studies leaves a facilitator behind the scene and gives him a lot of free time. To the contrary they cannot remain passive observers but become active partners and co-learners [9] involving in negotiation and exchanging of views [10]. A facilitator's role becomes "multidimensional, including being a ... manager, resource guide, expert, friend, advocate, authority, coach, and mentor" [11]. Students' roles change from being passive consumers to active participants and "co-designers" of their educational experience based on their needs and requirements [12]. The remaining part of this paper takes a closer look at the intervention attempt into higher educational setting carried out in an iCamp project. The following paragraphs focuses on facilitators' experiences, their tasks and responsibilities.

2 iCamp Intervention and Its Context

The iCamp project (www.icamp.eu) aimed at creating educational experiences for students and facilitators in a cross-cultural setting mediated by landscape of social media tools and services. It attempted to bring together on the one hand the use of social media tools and services and on the other hand the increased student control and responsibility with the purpose to provide students with opportunities to practice their competence advancement in the area of cross-cultural collaboration and self-directing intentional learning and change projects. This paper presents initial results of the iCamp intervention study from the facilitators' point of view.

The iCamp intervention ideas (see more detailed overview in [13] and [14] were implemented in an international, fully online Master's level "e-learning" course, which was part of an international Master's program (Interactive Media and Knowledge Environments) in Tallinn University and European Masters in Interactive Multimedia (EMIM) program. The objective of the course was to provide an insight into a course design process. The course consisted of a series of practical hands-on activities individually and in groups. In addition to the group work the students were introduced with conversational learning contract procedures [15] to support their individual and group tasks. The course lasted for 14 weeks.

Although, Moodle learning management system represents a typical centralised environment the facilitators were forced to make use of it due to the agreement among EMIM consortium members. Thus, in this course Moodle provided static information about the general course objectives, course outline, course schedule including the weekly tasks and assessment criteria. Moodle wiki was used to form students' groups. In addition to Moodle environment a more dynamic course Weblog in Wordpress was created with the purpose to notify the students with weekly tasks and other relevant information. One of the facilitators created a Scuttle account for bookmarking course related links and materials with predefined tags. The participants created personal Weblogs as personal studying/facilitation spaces. A referential set of social media tools and services that might be useful for the students and facilitators was provided. The participants had a free choice to use them for personal or group purposes, or find some other tools and services on their own.

In the "e-learning" course a lot of attention was paid on the reflection activities with the purpose to help the students to develop on the one hand deeper knowledge and skills with regard to the theoretical course material but on the other hand to advance their metacognitive skills and understanding of their learning habits and preferences. Personally created conversational learning contracts gave the students some insight to their learning progress and were a base for self-assessment. Second focus in the course was on cross-cultural collaboration, in which groups of students developed an artefact - a prototype of e-learning course.

The students of this course were given an increased control and responsibility for setting up their study goals, choosing reading material and creating a personal landscape of tools and services for supporting their study. In addition, the students had an opportunity to come up with their own evaluation criteria. 77 master students and 10 facilitators from different European countries participated in this course.

3 Research Design

This research followed elements of action research [16] and design-based research [17]. The study attempted to record a process of the intervention [18] from the facilitators' point of view. The purpose of the study was to qualitatively explicate perspectives and practices of the facilitators while participating in the "e-learning" course. The research tried to find answers to the following questions:

1. How did the facilitators engage in this „e-learning" course?
2. What are the experiences of the facilitators in this kind of course?
3. Which facilitation strategies did the facilitators implement?

Direct elicitation methods [18] were used for data collection focusing mainly on intrapersonal data such as facilitators' experiences, attitudes, thoughts about their facilitation styles and strategies. The data was gathered from the facilitators' personal Weblogs and semi structured online interviews.

Content analysis [19] of the facilitators' personal Weblogs was conducted to identify and quantify functional and structural properties of their Weblogs. The purpose was to find some indications to their overall facilitation approaches. The content analysis was based on [20] perspectives, which were customized according to the nature of this research setting:
- *Characteristics of the Weblog authors*, how much information about the facilitator appears in his/her Weblog;
- *Overall purpose of the Weblogs* according to the different facilitation styles. Based on the bottom-up analysis of the facilitators' Weblogs the Weblog posts were first coded according to the emerging patterns and on the second stage the codes were categorised into themes. The following themes emerged:

1. Posts about students' tasks - mainly repetitions of the students' tasks, which were also presented in Moodle system and in the course Weblog;
2. Posts about personal reflection – the facilitators' personal feelings, problems, achievements, questions in this course;
3. Posts about group work and its progress - descriptions of the group work progress, their achievements and problems, motivational encouraging messages;
4. Posts about explanation/advice/interpretation – the facilitators' interpretations about the reading material, tools, advices to the students as well as group related announcements such as meeting times for synchronous audio-video conferences.

If a single Weblog post consisted of information that belonged to many of the themes mentioned above, the dominant theme was taken into consideration. The Weblog posts were counted according to the themes and conclusions with respect to the overall purpose of the Weblog was made.
- *Structural analysis of the Weblogs* was carried out to count the number of images, posts and comments of the facilitators' Weblogs on a weekly basis (see Table 1).

In addition, a qualitative analysis of the facilitators' online interviews was done based on the [21] framework: data reduction, data display, and conclusion drawing and verification. The purpose of the online interviews was to find out the facilitators' attitudes and experiences as well as their facilitation strategies and their rational for this. The online interviews were transcribed and coded with the help of HyperResearch software. Bottom-up approach was taken, in which the emergent codes were categorized into a second level categories [18]. 9 out of 10 facilitators agreed to give an online interview. It has to be kept in mind that the purpose of this paper is not to analyse the influences of the facilitators' styles and strategies to the students' achievements and grades, but rather understand the outcome of an intervention as such from the facilitators' point of view. Instead, this paper concentrates on the facilitators' experiences, choices, success factors and problems in the „e-learning“ course setting.

4 Analysis and Discussion

4.1 Facilitation Strategies

The content analysis of the facilitators' Weblogs showed that the Weblogs were used in rather different ways. Every facilitator's Weblog started with a self-introductory post. The self-descriptions of the Weblog authors varied a lot from very detailed „biographies“ to rather general introductions. Most of them presented their personal and professional interests. 5 out of 10 facilitators uploaded their photos. It is very self-evident that self-introduction as a first contact with the students whether in written or oral format plays an important role in an online learning helping to build some sort of trust between facilitators and students.

Based on the analysis regarding the overall purpose of the facilitators' Weblogs, they were divided into four groups according the dominant theme. Four Weblogs (see Table 1) concentrated on *reminding the students with the weekly tasks* (theme 1). The majority of the posts repeated the description of the students' tasks or reminded the students what they should do. Thus, these facilitators took a rather passive role in the beginning to see how the students are going to carry out their individual tasks, and communicate and regulate their group work. The facilitator 10 said: „*I want to be a motivator and reminder. If there was no action I reminded them via my Weblog“* As long as the students performed their tasks on time, she stayed passive. As soon as the students started to loose interests, she stepped in to remind them their tasks either via her Weblog or e-mail. The facilitators claimed that the most efficient communication tool for motivating the students was e-mail. They explained that the open nature of the Weblog scared some of the students away. The facilitator 10 also decided not to have any kind of synchronous meeting due to the lack of technology in her group (cameras, headsets) and the students' fear of expressing their thoughts and ideas orally. Although, she claimed she felt a temptation to intervene while following her students, but she still decided to take an observer's role. She said: „*I didn't want to interfere with the group. Students asked me general things, not that much about the course prototype. If they couldn't solve problems they asked me*“. The facilitator 4 and 2 took similar approach: „*I joined the discussion if the students asked me, I helped them then they asked for it. I tried to be a good intermediator between the students and to increase their trust to others and to help them find a way to work together.*“

Two Weblogs (see Table 1) consisted of mainly facilitators' *reflections* (theme 2)**,** in which one of them was concentrating on her personal experiences in this course following the same reflection template as the students. The facilitator 3 tried to conflate the group as much as possible. She became an equal member of the group and was part of the group work. She claimed: „*I think we are moving towards this direction that we don't have just one smart person and the rest of us just listen to him. I think we should all learn something from this and do the reflection tasks. If the students were asked to write down their learning contracts, I should also think about my*

Table 1. Frequency of the posts/comments in the facilitators Weblogs

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*
Before the course	1/1		1		2	1	1	1	7/7	2/2
1 week		1/1	2/9	3		1/7		1		
2 week	1/3		1/13	1	1	1/3		7/3	3/2	4/2
3 week	1		1/1		2/2			7/3	1	6/4
4 week		2/1	2		5/3	3		4/3	5	1/7
5 week			1/6	2/2	4/5	1	5/5	2	2	1/2
6 week	2/5	1			1/1		2	4/1	3/4	4/1
7 week	4/6	1	1/2		1/1		2	5/4	2	
8 week	3/4	1	1/2		1/1				1	1/4
9 week					1/1			2		
10 week					1/1		1/3	2/1	2	
11 week			1		1	1		2/3		2
12 week	1/1				1/3				1	1/2
13 week								2/2	1	
14 week										
After the course		1		1				1		1
Overall purpose of the Weblog according to 4 themes	1	1	2	1	3	4	4	2	3	1

The first number indicates the number of Weblog posts in a particular week for every facilitator and the second number indicates the number of comments.

own goals and why I am here and why I am doing this." She was different from the other facilitators as she put a lot of effort on commenting as many students Weblogs as possible. She tried to justify: „*If we ask the students to do their tasks in their Weblogs, we should also give comments on these and give feedback*".

The other facilitator (8) was mainly writing about her thoughts and ideas that were triggered from the students' individual and group work. The facilitator 8 claimed that she attempted to make use of her personal Weblog for group collaboration. She also sent e-mails to her students to notify them about a new post she had published in her Weblog. The facilitator 8 explained that she decided not to write comments to her students' Weblogs, but use her personal Weblog for reflecting on her students' Weblog posts. She claimed that this gives an opportunity for the other students to learn something from these posts: „*I took some relevant sentences from the students Weblogs and commented it in my Weblog*."

Furthermore, two Weblogs (see Table 1) focused mainly on students' *encouragement and motivation* (theme 3) trying to explain the reasons and consequences of different students' activities. It turned out that the facilitator 5 got the most problematic group and she put her main effort on encouraging and motivating the students to continue with the course. Thus, she tried to clarify the tasks by sending e-mails and present a positive attitude towards this course and its tasks in her Weblog.

The emphasis of the last two Weblogs (see Table 1) was primarily put on *advices and interpretations* (theme 4) of the group work. The facilitator 7 said: „*I tried to create a kind of chain: to start with those who is able to start himself, who is motivated and active, and to make them pull into the course another person. I didn't want to force, I understood my role was only facilitating, not a teacher or anything*." He admitted that „naked force" has nothing to do with an online course, where you cannot force people to work.

Although the division of the Weblogs and the aforementioned facilitation strategies are somewhat artificial, they still reflect the facilitators' approaches and their conscious or unconscious decisions to a certain degree. The Table 1 shows the results of the structural analysis of the Weblogs indicating the frequency and the number of the posts with comments every week. From the Table 1 it can be seen that the facilitators made more intensive use of their Weblogs in the beginning of the course. But as soon as their groups moved to the group regulation environment, the facilitators left their Weblogs unattended. It is also interesting to note that there were some Weblogs, which got many comments while others only a very few. However, in general it can be concluded that most of the facilitators' Weblogs were consciously directed to their group of students.

4.2 Facilitators' Experiences

All the facilitators claimed that it was a useful and very educative experience. They appreciated the opportunity to collaborate with international colleagues and students who came from different countries with different cultural and language backgrounds, with different experiences and learning/teaching habits. It was the first time for all of them to work in such a heterogeneous setting mediated by the landscape of social media tools and services. However, it has to keep in mind that it was an artificially created experience, in which 10 facilitators from 8 different European institutions participated in a joint course. Furthermore, all the facilitators claimed that they would participate in similar courses because now they have an idea of what it means to facilitate such a course. This experience showed them their limits as well as potentials. One of the facilitators said: „*I would like to have another chance in this course, because now I already know the strong and week sides of this course and myself*". *I think it is interesting to have a new redesigned course, learn from our mistakes*". Although, some of them admitted that facilitating such a course was rather demanding, the others claimed: „*Absolutely, I would do this again, it is more difficult than a normal way, it is more exciting, because it is not clear…*" Excitement, innovativeness, creativity were the appealing keywords about such an intervention what would encourage them to participate again.

4.3 Lessons Learned

Being a rather new experience the facilitators claimed that they gained even more than they had expected, not only from the innovative situation itself, but also from the „e-learning" course participants. Besides of the possibilities of using and implementing various social media tools and services in studying and teaching practices, the facilitators also realised that this brings along a new notion of teaching and a new understanding of their roles.

A number of facilitators pointed out the difference of being a teacher in a traditional setting and being a facilitator in this course. They perceived that traditional way of teaching is not applicable anymore and there is a need to take a different role. One facilitator experienced: „*In the beginning you are worried about your role. You have lot of ways to be a facilitator and you can't be sure if the way you choose is correct. You must find your own way, you must search for it…and maybe for each group you have to be a different facilitator*." Thus, the facilitators having not much of the experiences and knowledge of how to facilitate, they felt insecure. It meant continues searching and testing of their facilitation strategies. One facilitator claimed that this course opened her eyes with respect to the problems in curriculum and traditional systems. She realised that this has hindered her to see the real potential of her students.

Furthermore, one of the facilitators said: „*I have learned something about barriers, about sources of problems, both in aspects of intercultural or maybe even educational differences, also language problems, my consciousness of some problems and the possibility of expressing this.*" Two facilitators admitted that the differences between countries regarding cultural varieties are not so obvious, but instead the educational systems vary a lot. Therefore, such differences should be kept in mind while planning such a course.

4.4 Main Shortages

Despite of the positive feedback regarding the overall course design, the facilitators also pointed out some shortages. The main problem for most of the facilitators was related to their engagement to the course (intervention) design and their preparation for the course. The facilitators experienced that only one face-to-face meeting among the facilitators was not enough to get a common understanding of the whole course as well as their tasks and responsibilities. They claimed that: „*We need more directions of what we have to do. We must be very well introduced into the course and the facilitator must know every corner of the course*". One of the two facilitators who was involved in designing the course (intervention) experienced: „*The most important thing is the common understanding, the attitudes and orientations towards this kind of setting. I think this is very important while doing this kind of course*". She felt that the group of facilitators was very heterogeneous with different knowledge and attitudes and different perception of their tasks and responsibilities.

Although the facilitators' tasks for every week were presented in the facilitators' Web-based workspace, it was not clear for them what they have to do. It resulted them feeling uncomfortable and insecure. They questioned about their responsibilities and their facilitation strategies: „*What should a facilitator do, what are the central facilitating activities that should be done, how to overcome the common problems, when should facilitators interact, when is the right time and at which level should the facilitator include himself into the activities?*" As mentioned earlier by one of the facilitators, facilitating such a course is an ongoing search process for the right approach. Besides, some of the facilitators were not familiar with the social media applications and thus they had problems with working with too many tools and services at the same time. In the beginning they also did not understand the reason behind this.

5 Conclusions

It is obvious that designing challenging experiences for students with the purpose to support the attainment of domain independent competencies a facilitator (instructional designer) has to move beyond the barriers of institutional learning management systems and traditional instructional design. This paper described the intervention into an international online course and its consequences from the facilitators‘ point of view. The intervention embraced a shift of control from facilitators to students or group of students in a technologically mediated setting.

Facilitating cross-cultural student groups with increased student control and mediated by social media tools and services is a challenging and new task. Despite of that the facilitators were satisfied with the experience and would like to repeat it mainly because of its underlying ideas and innovativeness. The facilitators showed rather different facilitation approaches from being a reminder to the students up to an equal member of the group. Nevertheless, it can be noted that most of the facilitators took a rather passive role to see how the students are going to manage their collaboration and individual tasks. Most of the facilitators intervened only if they were asked for it or if they noticed that their group needs some direction and guidance.

However, it is important to note that this paper concentrated only on the facilitators' strategies and their overall experiences in such a course. Therefore, it does not allow to make conclusions about the efficiency of different facilitation strategies, but it rather gives some „food“ for redesigning the course and think about facilitators' preparations, tasks and responsibilities while implementing such interventions.

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Are Tags from Mars and Descriptors from Venus? A Study on the Ecology of Educational Resource Metadata

Riina Vuorikari[1,2], Martin Sillaots[3], Silvia Panzavolta[4], and Rob Koper[2]

[1] European Schoolnet, Rue de Treves, 61,
1040 Brussels, Belgium
Riina.Vuorikari@eun.org
[2] Open Universiteit Netherland
P.O. Box 2960, 6401 DL Heerlen (NL)
{Riina.Vuorikari,Rob.Koper}@ou.nl
[3] Tallinn University Centre for Educational Technology
Narva mnt 25, Tallinn, Estonia
martin.sillaots@tlu.ee
[4] Agenzia Nazionale per lo Sviluppo dell'Autonomia Scolastica (ex INDIRE),
Florence, Italy
S.Panzavolta@indire.it

Abstract. In this study, over a period of six months, we gathered empirical data from more than 200 users on a learning resource portal with a social bookmarking and tagging feature. Our aim was to study the interrelation of conventional metadata and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and all stakeholders that included the managers, metadata indexers and the whole community of users. We found an interplay between tags and descriptors and showed how tags can enrich and add value to multilingual controlled vocabularies in various ways. We also showed that, even if many tags can be seen as redundant in terms of the existing LOM, some of them can become a useful source of metadata for repository owners, and help them better understand users' needs and demands.

Keywords: Learning resource metadata, tags, folksonomy, clickstream, thesaurus, evaluation.

1 Introduction

A conceptual model and taxonomy for social tagging system was presented in Marlow et al. [1] where the authors argue that tagging is motivated both by personal needs and sociable interests, e.g. attract attention, self presentation, future retrieval, contribution and sharing. Vander Wal [2] observed that tagging could be used to compensate for missing terms in a taxonomy and Lin et al. [3] and Al-Khalifa et al. [4] explored the overlap of tags with controlled vocabularies and automatic indexing. Sen et al. have studied the quality of tags and tagclouds in [5], Farooq et al. [6] focus on folksonomies

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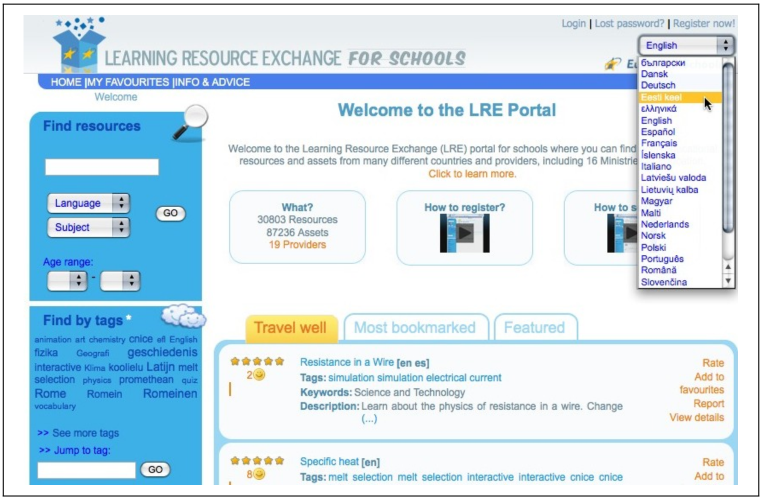

Fig. 1. The Learning Resource Exchange portal is available in different languages

adding intellectual value to a tagging system, whereas Heymann et al. [7] observe that tags are present in the page text of 50% of annotated pages and in 16% of the titles.

The quality of tags, like metadata, can be evaluated from two different perspectives: the validity of the metadata in describing the resources, and their usefulness in terms of searchability and the extent to which the metadata supports the retrieval of resources [8]. In this study, we are interested in how useful the user-generated tags can be for the learning resource "metadata ecology". This term can be used to describe the interrelation of conventional metadata (e.g. LRE Application profile) and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and stakeholders, such as the managers, metadata indexers and the whole community of users.

In the remaining part of this Section, we describe the context of the study and the data set. In Section 2 we presents the results of a number of studies with different stakeholders in the learning resource economy, including end-users, librarians/expert indexers and repository owners. Section 3 provides a discussion on the findings, whereas Section 4 concludes with possible future work.

1.1 Context and Method

The portal under consideration is the Learning Resource Exchange (LRE) (http://lreforschools.eun.org) developed by European Schoolnet and its partners in the MELT project. At the time of the data gathering (Jan 31 2009), a version of the LRE federation of repositories was made available to a restricted number of schools with more than 30 000 open educational resources and nearly 90 000 assets from 19 content providers in Europe and elsewhere [9]. These resources exist in different languages and conform to different national and local curricula. A common Learning Resource Exchange Application Profile [10] is used by content providers which

Table 1. Resources bookmarked and tagged on the LRE portal during the period from July 1 2008 to Jan 31 2009

	Distinct item	Number of times
Bookmarks	1857	2490
Tags	3832	9219
Tags clicked	419	3631

makes the use of classification keywords from the LRE Thesaurus mandatory [11]. This Thesaurus currently exists in 17 languages.

Figure 1 shows the front page of the LRE portal (hereafter referred as portal). The portal offers different categories of searches: "Explicit search" and "Browse by category" that take advantage of multilingual metadata. "Community browsing", on the other hand, takes advantage of the other user behaviour. This includes: the use of tagclouds and tags; social navigation features such as "most bookmarked resources"; and "Personal search" where users can search the resources they have previously saved in their Favourites by using tags.

The data set was gathered using a logging scheme for users' attention metadata, details of which can be found in [12]. The current data is a snapshot from a six-month period. From July 2008 to January 2009, primary and secondary school teachers from Austria, Belgium, Hungary, Finland, Estonia, United Kingdom, Slovenia, Sweden, France, Germany and Greece became involved in the pilot test. In total this meant 234 users out of which 77 used the bookmarking and tagging tool. Table 1 shows the number of bookmarks and tags produced by the users, and the amount of attention metadata that tags generated.

2 Results

We first look at how teachers tag and interact with tags on the portal. Then, we provide two different evaluations on tags, one by expert indexers and another one by a focus group of learning resource repository owners.

2.1 How Do Users Tag?

The basic dataset on users' tags is presented in Table 2. Out of all users, 33% added bookmarks and tags. In total, 1857 distinct resources were bookmarked 2490 times out of more than 30 000 learning resources made available. On average, each resource had 1.3 bookmarks; however, in reality, 80% of resources had only one bookmark. The remaining 20% accumulated 53% of all bookmarks. Each bookmark had an average of 3.7 tags (Table 2). When we look at the tags per resource, we find each resource has an average of 5 tags. However, the top 39% of resources had 70%

Table 2. Average tags per bookmark, average tags per resource, and how users tag on average

Average bookmark	Average resource	Average tag	Average user
3.7 tags	5 tags	2.4 applications	28 bookmarks, 118 tags

Table 3. Language in which users add tags, the language in which the tagged content exist and the percentage of users coming from different countries. 12% of content was either multilingual or language independent.

N=3738 tags	UK(en)	Hu	At (de)	Fr	Be (nl)	Sl	Fi	Se
Language of Tags	29%	24%	7%	6%	6%	5%	3%	4%
Language of content	18%	35%	32%	<1%	n/a	<1%	n/a	<1%
% of users who tag	2%	78%	5%	0.1%	5%	0.5%	1%	0.2%

of tags and the remaining 61% of resources had less than five tags (18% had only one tag).

There were 3832 distinct tags applied 9219 times. On average, each tag was used 2.4 times. 15% of tags were used more than average; these tags comprised 59% of all tags applied. There were three tags that were applied more than a hundred times, namely "english" (257), "interactive" (161) and "Vocabulary" (126). Each user who bookmarked (77) added an average of 28 bookmarks. The top 28% of users were responsible for 85% of all bookmarks, whereas 72% users were below the average. An average user applied 118 tags to bookmarks. We find, however, that 29% of users added over 92% of all tags, whereas 71% of users were below average.

As the LRE portal is made available to teachers from European countries and its interface is made available in multiple languages, it is normal that users tag in multiple languages. With the help of the LRE Multilingual Thesaurus, we verified the language of the applied tags in a sample (n=3738). Table 3 shows the languages that were used for tagging. 29% of the tags were in English, although a very few users had English as mother tongue. We found a medium correlation (r=0.57) between the language of the content and language of tags. The tagging behaviour in a multilingual context is further studied in [13].

We ran a database query against all the tags and the multilingual Thesaurus terms. We found that 11.3% of distinct user-generated tags exist in the LRE multilingual Thesaurus. We call these "Thesaurus tags", as they are end-user generated, but they also exist in the Thesaurus. The number of times "Thesaurus tags" were applied rises to 30.6% of all tags (i.e. the same tag added to many resources). On average, these tags were reused 11.8 times compared to other tags which were reused on average 2.4 times. In the following evaluations we see the popularity of these terms is repeated (e.g. Table 5). It is interesting that, especially in a multilingual context, such a high percentage of overlap exists between natural language and controlled vocabularies. In [4] authors report that the folksonomy set overlapped with the indexer set on average 19.5%.

2.2 What Do Users Actually Click?

Table 4 shows that 58% of all users had clicked on tags while searching for resources, whereas 42% never used tags. This means that more people use tags for retrieval than actually add tags (33%).

Table 4. Users of the study: 33% of users tag and 58% of users take advantage of tags for searching purposes

Users=234	Uses tags for searching	Does not use tags for searching	**Total**
Users don't tag	74	83	**157 (67%)**
Users tag	64	14	**78 (33%)**
Total	**137 (58%)**	**97 (42%)**	

Table 5. Most added and clicked on tags on the LRE portal. "Add to LOM" shows the most voted tags by expert indexers to be added to LOM. * indicates the potential "Thesaurus tags" and ** indicates tags that were not added by the end-users, but project staff.

Tag	Added	Tag	Clicked	Tag	Add to LOM
english*	294	melt selection**	498	english*	90
interactive*	173	promethean**	371	vocabulary*	80
vocabulary*	136	english*	185	NewYork	75
angol*	94	interactive*	119	french*	73
efl	91	animation	109	young_learners	70
SDT	91	Deutschland*	77	képleírás	70
grammar*	69	cultural_background	76	Europe*	67
informatika	58	may10**	76	esl	66
animals*	57	history*	71	interactive*	60
quiz	53	koolielu	66	photo*	60

For the resource discovery, we were interested in whether all the tags were used in a similar way. Out of more than 3800 distinct tags, our logging analyses show that 419 tags generated 2631 clicks of attention metadata, i.e. clickstream. On average, each tag received 6.9 clicks; however, in reality, the top 14% of tags that were above average generated 76% of the clickstream. In Table 5, in the middle column, we find the tags that generated the most clickstream. There were three end-user added tags that rose above others (english, interactive, animation), which also probably constitute the "wish list" of the users of an international learning resource portal.

As for Community browsing, we find that not only tags attract clickstream, but bookmarks are also used for social navigation. By registered users, tagcloud receives 22% of all search actions, whereas personal bookmarks 5% and another additional 2% come from clicking on other users' bookmarks. This shows that to a small extent, tags are used to discover resources by other users, but also for Personal searches.

Lastly, we asked whether the tags that were added a lot by users, also received users' attention. In the other words, does the offer of tags by teachers match the demand by teachers? We devised a measure for "attractive tags" which compared the *amount of clickstream on a tag* to *how many times it had been added* by teachers. If the number is above one (1), it means that the tag has generated more clickstream than tag applications. This means that the tag is "attractive". If the number equals to one, it means that there is an equal amount of both, and below one indicates that there are tag applications, but no demand. We found that 21% of tags were "attractive" (Figure 2) and 24% had an equal demand and offer. 55% of tags received less clicks than there were tags applied to resources. Language-wise, within the "attractive" and "equal" tags, 28% are in another language than English.

2.3 What Do Expert Indexers Think of Tags?

Out of the original dataset, we took a sample of ten learning resources with user-generated tags that a) had a high number of tags and/or b) offered some variety in terms of discipline and type of resources. This data was used in order to obtain feed-back from 15 expert indexers who work with metadata and classification of resources in a learning resource repository or portal. The details of these evaluations are reported in [14]. There were ten resources that included 23 Thesaurus terms as descriptors and 88 tags. We asked the indexers to *evaluate the usefulness of end-user created tags as descriptors of learning resources*.

In general, we detected that expert indexers were positive towards tags; they were evaluated as being suitable (i.e. clear and unambiguous) as indexing keywords (average 30%) and were actually added to the original LOM description (average 26%). The "Thesaurus tags" featured prominently (43%) among tags that expert indexers voted above average on the question "Would you want to revise the original LOM description of the resource and, if so, which of the following terms might you adopt" (Table 5, right column). Especially in the case where the original indexing was poor or limited, for example, due to too broad indexing, participants in the study indicated that they would be prepared to adopt these "Thesaurus tags". Examples of these tags in our analyses are: chemistry, culture, Európa, Europe, grammar, information, kemia, kultúra, reading, szobor, thermodynamics, vocabulary.

There were also *potential Thesaurus tags* – some tags that have an almost identical spelling to Thesaurus terms; however, these cannot be identified automatically, but require human intervention. Examples are tags such as "english" which could be mapped to Thesaurus term "English language", or "french" to "French language".

2.4 What Do Repository Managers Think of Tags?

A focus group with five learning resource repository or portal managers was run to better understand how they perceived the value of tags. These are reported in details in [14]. One of the activities was a small case study where a repository manager analysed the added value of tags to existing Learning Object Metadata (LOM). The case in question is the Tiger Leap Foundation's repository which is part of the LRE federation. The study comprised 84 bookmarks on 63 distinct resources where users from different European countries had added tags to them. The tags were compared with the existing LOM, its keywords, LRE Thesaurus terms and other classification information such as curriculum topics.

In 25% of the cases the tags provided additional value for the repository. Tags, for example, described the content of the resource more clearly (tags 'Australia' and 'USA' added for the resource "English-speaking countries", or 'culture', 'nature' added for a resource titled "Scotland"). Even if our sample size is very small, the results point in the same direction as previous studies, e.g. [6] compared tags with the page text and back and forward link page text, and found that in 20% of the cases tags provided search data not provided by other sources.

Moreover, we was found that in 49% of the cases, the information that the tags provided was already reflected in existing keywords, LRE Thesaurus terms or in other classification information, and in 26% of the cases tags included somewhat redundant information, which already existed in other elements of LOM description. The following redundancy was observed with elements of the LOM description:

- LOM 5.2: resource type (e.g. photo, picture; exercises, games; simulations; quiz, web quest)
- LOM 5.7: the age group being addressed (e.g. young learners)
- LOM 1.3: the language of the resource (e.g. English).

3 Discussion

In this study we have focused on the interplay of tags and Learning Object Metadata descriptions that takes place on the learning resource portal. We have looked at the issue from multiple points of view, namely that of end-users, expert indexers and repository managers. We have shown a number of levels where possibilities for interplay exist. A number of interesting issues arise. We have found that a third of tag applications by the end-users are actually descriptors that exist in the LRE Multilingual Thesaurus. These "Thesaurus tags" by users can be used to improve the semantic interoperability of tags. First, they have a potential to be used as a "bridge" between existing descriptors and tags, and thus enhance the semantic interoperability within and across languages.

One example is the resource "Change of State" in Figure 2, which has tags by end-users as well as the classification terms by the expert indexer. Table 6, on the other hand, shows the Thesaurus "descriptor 195" representing the concept of "chemistry" with its language equivalences. As we can now observe, the tag "*kemia*" is actually a "Thesaurus tag". Thanks to the multilingual Thesaurus, we can first of all recognise the similarity between a "Thesaurus tag" and the descriptor, and then assign properties to these tags from the Thesaurus, e.g. the tag "*kemia*" is related to the concept of "descriptor 195" and its language is Finnish. A similar idea of connecting tags to existing ontologies has been presented in [15], although the difference is that in our case, we use the resource and its existing descriptors as a proxy for the semantic link between the descriptor and tag, and that this process can be automated to take place at the back-end without being intrusive to the user.

The information gained from the link between the "Thesaurus tag" and descriptor can be used in various ways. It can be used, for example, in the tagcloud to show different translations of the tag "*kemia*". As for the retrieval purposes, the system

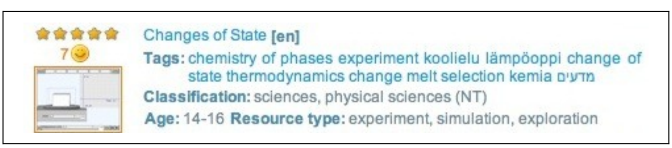

Fig. 2. Learning resource "Change of State" with tags (e.g. "*kemia*") and indexing terms "sciences" and "physical sciences" from the multilingual Thesaurus

Table 6. Language equivalences for the Thesaurus "descriptor 195", including also one user-generated "Thesaurus tag" kemia

Descriptor ID	Lg equivanances	
195	Chemie	fr
	chemistry	en
	kemi	sv
	kemia (Thesaurus tag)	fi
	kémia	hu

could infer that other resources indexed with the "descriptor 195" are also relevant. Here, the user will get a chance to retrieve learning resources in multiple languages, thanks to the inter-language connection that the multilingual Thesaurus offers. Moreover, they open up new options to navigate across multilingual resources as, for example, we could imagine displaying all the tags that are related to the "descriptor 195" to create a multilingual chemistry tagcloud.

Secondly, the "Thesaurus tags" can be suitable descriptors to be added to the original LOM description of the learning resource, particularly in cases where the original indexing has been poor or limited. In our example of "Change of State", we know from the Thesaurus hierarchies that the "descriptor 195" is a narrower term of the existing indexing term "physical sciences". As the "Thesaurus tag" narrows down the current classification of the learning resource in question, we can automatically add it as a new classification term for the resource.

Thirdly, the area of intra-language equivalence within the multilingual Thesaurus could be improved with tags, as in our evaluations they have been identified as a good source for non-descriptors. A non-descriptor provides the intra-language equivalence that facilitates access to resources that are indexed by using the thesaurus terms that do not translate well to the language that the end-user uses. For example, the tag "efl" (= "English as foreign language") could be expressed in thesauri terms as "English language" + "foreign language". When the user types a text search "efl", not only tagged resources would be retrieved, but also the ones with the above descriptors. In this way the gap between natural language and controlled language could be reduced. The same could apply also for gathering better scope-notes, which deal with the meaning of terms and help the user to understand the term better. Especially in a multilingual context, where some differences occur from one language/culture to another, this feature is useful to understand cultural differences.

Lastly, in the area of interplay between the tags and Thesaurus, the Thesaurus enrichment should be noted. Tags can help to define, verify and enrich, and then redefine a number of relationships in thesauri. Our evaluations have shown that tags can help identify areas in the Thesaurus where descriptors are not sufficient and thus need enrichment.

We have also shown that tags can yield important information for the repository owners. In the case study we showed that a small number of tags added value to the existing LOM by better clarifying the content and thus enriching it. The fact that many tags were redundant with the existing LOM description, on the other hand, can make an interesting case for generating a more complete LOM description automatically from the tags. The clickstream generated from the users' attention could be used to indicate areas in which the users have current interest and thus help the repository manager to display a larger number of potentially relevant resources. Lastly, seeing the popularity of some tags in the tagcloud (e.g. English, interactivity), the repository managers could also take advantage of the other elements of LOM (e.g. type, language, classification keyword) navigation paths à la tagcloud, which seem to be very attractive for users. Finally, we note that tags interplay with end-users by allowing them to create their own "eco-scape" of resources by using tags in a way that Marlow et al. [1] call "self presentation". This enhances the personal retrieval of resources and thus allows users to claim more ownership of resources. This type of "ego-scape" can further be used by other users to discover resources.

4 Conclusion and Future Work

This study has helped us to better understand the "metadata ecology", a term that can be used to describe the interrelation of conventional metadata (e.g. LRE Application profile) and social tags on the one hand, and their interaction with the environment, which can be understood as the repository, its resources and stakeholders We found interplay between tags and descriptors on the one hand, and on the other, we showed that tags can enrich and add value to multilingual controlled vocabularies as the multilingual LRE Thesaurus. We also showed that tags can become a useful source of metadata for repository owners, as well as help them better understand users' needs and demands through appraisal of "attractive tags".

Having established in this study that not all the tags are as far from the Thesaurus descriptors as Mars is from Venus, future work should particularly focus on improving the link between tags and terminological knowledge base such as the LRE thesaurus. Tags have been created in a specific cultural context where educational language is used, and thus are valuable as a way to reduce the gap between natural and controlled languages. Moreover, further work should focus on the inherent connections between tags and resources to support and enhance the discovery of learning resources across contexts.

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Unit of Learning Model for LMS/LCMS Integrating Psycho-pedagogical Elements

Kai-li Wang[1,2] and Philippe Trigano[1]

[1] UMR CNRS 6599 Heudiasyc, BP 20509, Université de Technologie de Compiègne, 60205 Compiègne，France
[2] School of Educational Technology, Shengyang Normal University, 110034, Shenyang, Liaoning, China
kaili.wang@hds.utc.fr, philippe.trigano@utc.fr

Abstract. In order to make Learning Management System (LMS) and Learning Content Management System (LCMS) more adaptable, this paper provides a way of integrating psychological and pedagogical elements in the online course structure generation process, based on platform of netUniversité. The elements are integrated in an interactive user questionnaire, which is based on the results of quantitative research. As a part of user model and the preface of learning design, this questionnaire was presented in an ontology, to solve the problem of combinatorial explosion.

Keywords: Unit of Learning, adaptability, netUniversité, pedagogy.

1 Introduction

With the development of Learning Management System (LMS) and Learning Content Management System (LCMS) in the domain of e-learning, many tools as applications were designed with the function of creating, publishing and managing one's online courses. They are provided to online instruction designers, teachers and learners. Many tools focus on learner's profile while few attempts have been done to consider the versatile profiles of other important educational practitioner (teacher and designer). One reason is that teacher's cognitive and epistemological knowledge make a complex influence on his/her decision making. Another reason is: psychological preferences are hard to normalize or modelize as the implicit elements influencing the learning design. For example, user's preferences differ from other user model components in several aspects, the preferences cannot be deduced by the system. The user has to inform the system directly or indirectly (by a simple feedback) about such preferences. In this sense, it is more adaptable than adaptive [1].

As an LMS/LCMS, netUniversité was initially designed for the teachers who have not enough competence in web development [2]. This system makes it possible to generate course structures, to edit pedagogical content and to instantiate, run and administer their courses.

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The construction of netUniversité platform is based on IMS LD [3], which is the *de facto* standard of learning design. Normally, an LD specification for a UoL is designed to be independent of any delivery environment including highly contextualized adaptive educational hypermedia systems (AEHS). In AEHS, teachers will be involved in work directly on UoLs [4] during design time, not only as real teachers during the run time. The modelling of the UoLs will be meanwhile influenced by the designer (teacher)'s belief and background. The research in this paper concentrates on the work of integration of psychological and pedagogical elements into this platform, making the system more adaptable. The UoL will be modelled inform of online courses with these elements.

2 Research on Thinking Mode, Domain of Application, Teaching Styles and Pedagogical Activities

Teacher's belief in pedagogical aspects will be directly embodied on the pedagogical activities. The term of "pedagogy" generally refers to strategies of instruction, or a style of instruction. It is the "science of teaching" and concerns itself with good practice in teaching and learning. One of the main goals of AEHS is to facilitate effective teaching and learning, while the use of variety of teaching strategies can minimise "turn off" learning approaches. E-learning by AEHS offers many new pedagogical possibilities.

In netUniversité, the starting point of pedagogical scenario construction can be found at the first stage of the generating process of online course structure. The structure is defined by different pedagogical elements (detailed in 2.5). Therefore, we consider the pedagogical activities as the focus because they play the role as the basement of online courses. The following research discovers how to help teachers make decisions for pedagogical activities with psychological and pedagogical elements.

2.1 Research about Teaching Style

Hoyt and Lee have defined teaching style as the way by which various teaching approaches are combined [5]. Each "style" resembles a "recipe" in which the ingredients are pedagogical approaches. Dunn and Dunn stated that "teachers teach the way they learned" [6]. This conclusion is supported by Witkin [7] and Gregorc [8]. Furthermore, Fuller pointed: if the instructor's preferred style of interaction is known, the course design and the types of learning and interaction activities can be selected to meet both instructor and learner needs [9]. Teachers develop the teaching style based on their beliefs about what constitutes good teaching, personal preferences and abilities, and the norms of their particular discipline. Van Tilburg and Heimlich have also defined two domains of an individual's teaching style; one of them is the inclusion domain which is based on the teacher's willingness and ability to utilize instructional strategies [10].

Depending on the research above, to study teaching styles, we use a teaching style model of Felder-Silverman, similar to learning style model [11], which is often used in educational system with learning style adaptation [12]. There are five dimensions in this model, in accordance with the way of information treatment:

- concrete/abstract (the content of the presentation)
- visual/verbal (the mode of presentation is stressed)
- inductive/deductive (the manner of organization of the presentation)
- active/passive (the mode of student participation facilitated by the presentation)
- sequential/global (the type perspective provided on the information presented)

By combining the poles of different dimensions, 2^5 types of teaching style can be distinguished.

2.2 The Classification of Domain of Application

Up to now, there is no standardized classification for the category of curriculum in university, although the educational organizations or institutions have their relative "mature" and practical system. Based on the research on Information and Communication Technology in Education (ICTE) of UTC (Université de Technologie de Compiègne), France [13], the information from the organisation of UNIT [14], and the information of other organizations [15] [16], we classify university curriculum in seven subgroups of disciplines: Fundamental science, Engineering science, Communication/Languages, Life science/Biology, Earth science/Environments, Human and social science, and Management science.

2.3 Thinking Mode

For verifying the hypothesis of "the teaching styles, the preference for the pedagogical activities are influenced by thinking mode" [17], we will examine teacher's thinking mode by a tool which is inspired by the model of Herrmann Brain Dominance Instrument (HBDI®) [18]. In this model, human's brain was divided into four quadrants corresponding to four thinking modes (signified by colors of blue, green, red and yellow), and the activities they like are also listed in Table 1.

2.4 Pedagogical Approaches and Pedagogical Activities

We classify the general pedagogical approaches and their corresponding pedagogical activities in five categories, as in table 2:

Among them, "Behaviorist", "Cognitivist" and "Constructivist" are also the major approaches in designing instructional hypermedia. "Socio-constructivist" and "Active pedagogy" are the supplement approaches of the former three ones, to have extensive practical work.

Table 1. Classification of activities according to HDBI® model

Quadrant	Color	Prefered activities and working characteristics
Left cerebral hemisphere	Blue	Theoreticians: They like the facts, the details, critical thinking, the precise definitions, unambiguous instructions. *Characteristics of work: Works alone; analysis and diagnosis; presents a relational problem by the logic; solves difficult problems in matrix; likes challenges…*
Left limbic system	Green	Organiser: They love the instructions step by step, the schemas, checklists, Time Lines, problem solving with the steps and specific procedures. *Characteristics of work: likes structure; puts in the order; plans, organizes and manages "execution" of projects; preserves the status quo; attentive to details; integrates information in a sequential manner…*
Right limbic system	Red	The socials (Humanitarians): They prefer collaborative learning, group discussions, role-playing, personal approaches and personal examples. *Features work: Builds relations before constructing the project; loves persuade, advice, listen, be part of a team; expresses his ideas with emotion; sensitive to what other people think…*
Right cerebral hemisphere	Yellow	Innovators: They prefer brainstorm, metaphors, illustrations, images, summaries, holistic approaches, the pace (rhythm) alert. *Features work: Takes risks; experiments; loves the variety, energy, novelty; plans the future, likes to talk about strategy; uses his intuition; overview, interrelations…*

Table 2. Pedagogical approaches and pedagogical activities in netUniversité

Pedagogical approach	Pedagogical activity
Cognitivist	Presentation of the theoretical concepts and then the resolution of the exercises (and solution)
Behaviorist	Discover the theoretical concepts from the exercises and the case (from example)
Constructivist	Learning from project, in the context of an individual work (student-centred)
Socio-constructivist	Learning from project, in the context of a collective work (collaborative learning)
Active pedagogy	The cooperation between the students (each student communicates with his/her peers to seek help)

2.5 Decisions for Pedagogical Activities

In order to well structure the great volume of pedagogical information, after the analysis of different pedagogical website, in netUniversité, three types of UoL have been determined: presentation of the theoretical concept, exercises, and projects. They can be presented by the way of “online” or “download”. The decision for the combination of the course elements and their presentation way is based on the inference rules of ontology, so as to avoid combinatorial explosion phenomenon. This user questionnaire ontology could be considered as both part of user model and preface of learning design ontology. From this psycho-pedagogical tetrahedron (Fig. 1), the different combinations (paths) from the starting point of any arrow can be obtained. The path signifies the set(s) passed through, and the instances which we have chosen in the set(s) will become the final elements of a course. The center of this tetrahedron is pedagogical approach (PAp). If the teachers have not realized which kind of approach they adopt, they could neglect this element.

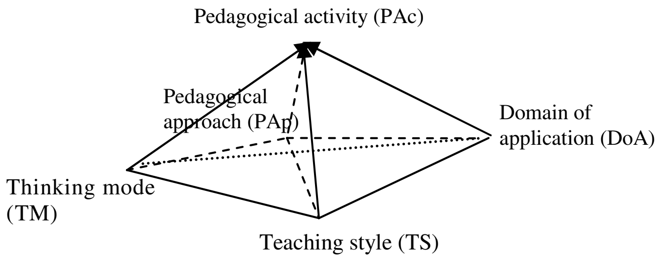

Fig. 1. Psycho-pedagogical tetrahedron

Take one of the inference rules in Protégé SWRL as example:

user(?u) ^ hasPedagogicalActivitesDM(?u,?m) ^
hasPedagogicalActivitesTM(?u,?n)→ hasPedagogicalActivites(?u,?m) ^
hasPedagogicalActivites(?u,?n).

According to this rule, if a user who works in certain domain and obtains his/her thinking mode result from the psychological questionnaire of our system, he/she could then be automatically provided the corresponding pedagogical activities automatically to structure his/her online course.

3 Psycho-pedagogical Questionnaires and UoL Model

The psycho-pedagogical questionnaire is shown in Fig. 2 as a part of upper concepts of user questionnaire ontology. The UoL will be modeled into a course composing these pedagogical activities. Once a UoL created, it is difficult to change or modify the inner resources and/or to add/remove services and resources at run-time. A lot traditional approaches create a UoL relying only on the expertise of the institutional designer. In netUniversité, with the modules based on both the theoretical research which we elaborated in previous sections, and quantitative research on paper questionnaire, interactive questionnaire give users a space to observe their own preferences and to choose pedagogical activities adaptively.

3.1 Construction of Psycho-pedagogical Questionnaire

This research began with the interview and paper questionnaire among 93 teachers in five universities of France and three universities of China. The interviewees are the professors or teachers who are responsible for certain courses in their universities.

In the questionnaire, a list of disciplines are provided, they all belongs to the seven branches (see Fig 2). Even only with the discipline information, users may be automatically recommended some course models by system.

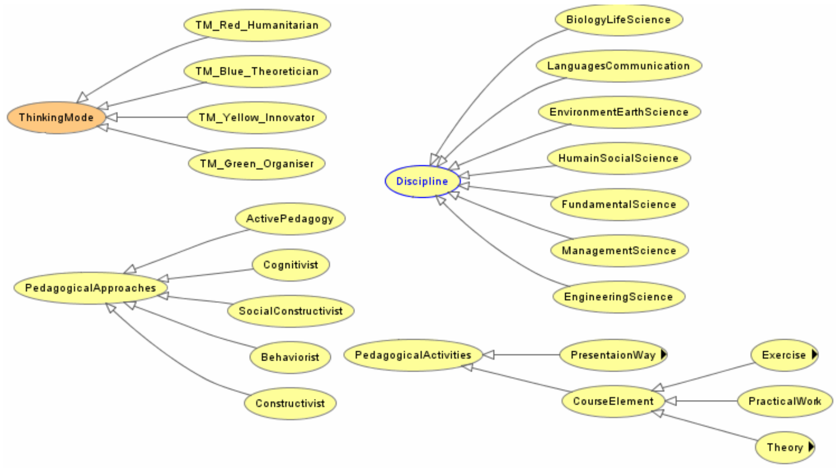

Fig. 2. Four parts of user questionnaire ontology

	ANALYSIS OF THE ANSWERS AND RESULTS	TOTAL				
		22	17	13	18	25
		RED	BLUE	YELLOW	GREEN	N.O.
1	I wear only comfortable clothes.	1				0
2	The way used to arrive at destination imports me little, what counts is to arrive!		0			0
3	The colour of my costume, it's important.	1				0
4	I like to have an agenda to know the subjects which will be discussed, the people who will present the subjects and time allocated at each subject.				1	0
5	I like the argumentations based on facts		1			0
6	I like that the things are spontaneous… the sentence which I generally use… we will see at the desired time….			0		1

Fig. 3. An example of analysis and result of the answers

The psychological questionnaire includes 128 daily questions; these questions are grouped into four colors (see Fig 3). "1" represents that the respondent agrees with the statement, "0" represents "not agree", we set certain weight (<0.5) for the third choice "no opinion", trying to observe the preference tendency more precisely.

Furthermore, we adopt a questionnaire transformed from ILS questionnaire [19] of Felder-Silverman as the model testing teaching style. After transforming, the questionnaire is more adapted to the netUniversité users with the questions such as "As a teacher, I would like to …" or "I find that it is easier to teach a)The fact. b)The concept", and so on.

Thus, the different possible results can be inferred in the user questionnaire ontology according to the inference rules.

3.2 Integration of the Questionnaire and Interview Results

The rules and the relations between different concepts of ontology are deduced from some quantitative research results of the paper questionnaire. From Fig 4, we can find the example of results: the tendency and the data improved that pedagogical activities will never exist independently from application domain and thinking mode.

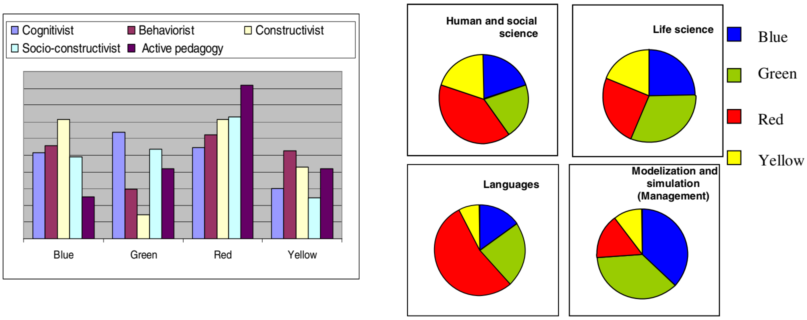

Fig. 4. The tendency of pedagogical approaches at different thinking mode and the percentage distribution of thinking modes in some disciplines

Also, the discipline and the pedagogical activities can be linked according to the analysis of paper questionnaire result.

This is an example: if a user has got his/her thinking mode “color blue”, system will identify it as a subclass of “Thinking Mode”, then infer its pedagogical activities according to its position in ontology and its relation with other concepts:

```
…
<owl:Class rdf:ID="TM_Blue_Theoretician">
     <rdfs:subClassOf rdf:resource="#ThinkingMode"/>
     <rdfs:comment rdf:datatype="&xsd;string"></rdfs:comment>
</owl:Class>

…
     <rdfs:domain rdf:resource="#TM_Blue_Theoretician"/>
     <rdfs:range>
        <owl:Class>
           <owl:unionOf rdf:parseType="Collection">
              <owl:Class rdf:about="#Exercise_PwS_Download"/>
              <owl:Class rdf:about="#PracticalWork_Download"/>
              <owl:Class rdf:about="#Theory_EA_Online"/>
              <owl:Class rdf:about="#Theory_SC_Online"/>
           </owl:unionOf>
        </owl:Class>
     </rdfs:range>
…
```

If the user utilizes more than one module to infer the pedagogical activities, the union of the final pedagogical activities will be integrated into the course. Fig. 5 shows a course interface for a user who has the thinking mode “color red” choosing a discipline of “Modelization and Simulation”.

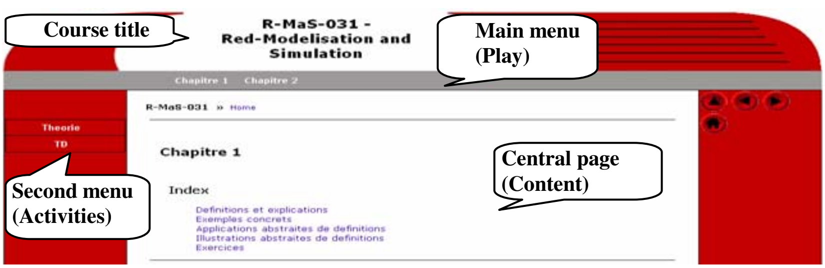

Fig. 5. An example of a course integrating elements of thinking mode and discipline

3.3 Scenario of Use

An interactive questionnaire is designed in netUniversité, with the modules of "Domain of Application", "Pedagogical Approaches", "Thinking Mode" and "Teaching Styles". The latter two propose series of questions from which users could obtain their thinking mode and teaching style. Consequently, certain pedagogical activities will be inferred and be recommended for generating the online course structure, adapting to the results they have just got. Thus the different pedagogical models can be manifested by UoL, in form of online courses. Fig. 6 [2][20][21] elaborates the process of the generation.

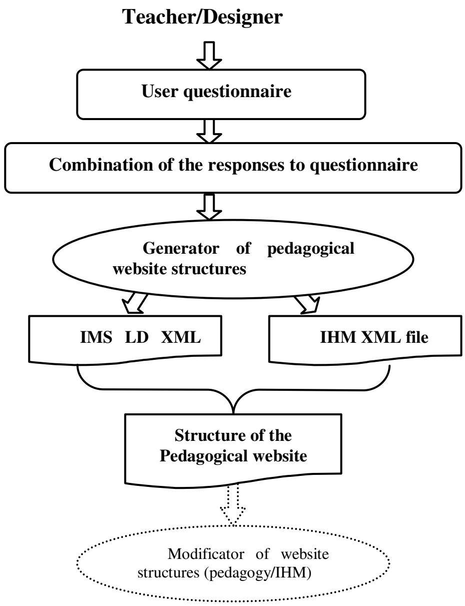

Fig. 6. Automatic generation of pedagogical website

Furthermore, in order to make our system more adaptable, we develop the module of modification, which make it easier to change the structure of pedagogical website. In other words, user questionnaire, together with module of modification, provides the user with different strategies to build their personal UoLs although the user may have neither much knowledge of website developing nor exact idea of pedagogical theories.

The model of UoL was represented by XML files. If the three pedagogical elements have been decided before, the course content can be edited by adding items in netUniversité by teachers. Also, the teacher could design their courses adapt to students' profiles. That is, teachers can also make their course more adaptive, which is not studied in this paper. Shortly concluded, what we emphasize here is the teacher's profile, not denying the importance of learner's profile in AEHS.

4 Conclusion

The LMS & LCMS researchers are usually ready to help the users (online course designers/teachers) find ways to optimally use technology to enhance their teaching, not for changing teachers' teaching styles, but to support them in the best way as they can. Our research considers the element of thinking mode, teaching styles, and other pedagogical aspects, providing adaptable pedagogical activities to the construction of the online pedagogical website. Because the provision of pedagogical activities is mostly based on the result of quantitative research through interview and paper questionnaire, the limitation of its use is inevitable. So, in the future, the research work will concern more extensive utilisation of our system, bridging the gap between teachers and developers, taking good advantages of the reusability of ontology and the further test of the teaching style in AEHS, together with other psycho-pedagogical elements.

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An English Vocabulary Learning System Based on Fuzzy Theory and Memory Cycle

Tzone I Wang[*,**], Ti Kai Chiu, Liang Jun Huang, Ru Xuan Fu, and Tung-Cheng Hsieh

Department of Engineering Science
National Cheng Kung University, Taiwan
wti535@mail.ncku.edu.tw

Abstract. This paper proposes an English Vocabulary Learning System based on the Fuzzy Theory and the Memory Cycle Theory to help a learner to memorize vocabularies easily. By using fuzzy inferences and personal memory cycles, it is possible to find an article that best suits a learner. After reading an article, a quiz is provided for the learner to improve his/her memory of the vocabulary in the article. Early researches use just explicit response (ex. quiz exam) to update memory cycles of newly learned vocabulary; apart from that approach, this paper proposes a methodology that also modify implicitly the memory cycles of learned word. By intensive reading of articles recommended by our approach, a learner learns new words quickly and reviews learned words implicitly as well, and by which the vocabulary ability of the learner improves efficiently.

Keywords: Extensive Reading, English Learning, Fuzzy Theory, Memory Cycle, e-learning, Personalized.

1 Introduction and Related Works

To build up vocabulary more and quickly with sustainability, the best way is not to remember the words brutally but to read extensively and often. The world record holder, who gets full marks in a TOEFL test and is now the chief writer of TIME Express (Chinese edition), Mr. Xuan suggests the best way to expand English vocabulary is to read articles extensively and try to figure out the meaning of an unknown word by the meaning of the sentence or even the paragraph which contains the word. An even better status is in enjoying the reading and building up one's vocabulary in the mean time.

This paper proposes a methodology that can help a learner quickly building up English vocabulary both by reading articles, during which meanings of unknown words are figured out from the context of articles, and by quizzing afterword, which

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checks if learners really understand the vocabulary in the articles. Beginners of English, however, usually know only a limited amount of vocabulary and phrases; it would be quite hard for them to figure out meanings of unknown words in an article beyond their ability. The approach proposed herein is based on the modern Item Response Theory, the IRT, and uses the one-parameter Rasch Model to recursively calculate the ability of a learner, and harnesses Fuzzy and Memory Cycle Theories to choose suitable articles, which are properly graded, for the learner [5] [6] [7] [10] [11]. After an article is read, vocabulary in it a reader in the article's level is supposed to have learnt are collected and, based on which, a quiz is held to check whether or not the reader understands the article, especially the vocabulary and phrases.

Quizzes after readings also serve to enhance the memory of vocabulary in articles, including familiar and newly learnt words and phrases. Learning memory cycles of a learner to the vocabulary in an article are implicitly adjusted. Memory cycles of words not in a quiz are also adjusted by the answers of questions containing other related words in the quiz.

The General English Proficiency Test, GEPT, in Taiwan has been operated by The Language Training and Testing Center, Taiwan and, since 2000, used by two and a half million people [9]. This research will use the same vocabulary and articles used in different levels of GEPT for different levels of English abilities. In addition to adjusting memory cycles of vocabulary, this research also infers the relationships between words in an article and intelligently adjusts the memory cycles of those words that do not appear in the after-reading quizzes but are known to a learner [7].

2 System Architecture

The system architecture shown in Figure 1 realized the approach proposed in this paper. There are two software agents, the *Learning Agent* and the *feedback Agent*, for controlling major processes executed by four main modules, the *Learner Ability Assessment Module*, *Article Recommendation Module*, *Quiz Generation Modules*, and *Memory Cycle Calculation Module*.

Learner Ability Assessment Module - uses the Computerized Adaptive Testing, the C.A.T, approach to figure out the English ability of a first time user by Ten questions and then one-parameter model of Item Response Theory and maximum likelihood estimation method to evaluate the vocabulary volume of a learner. This

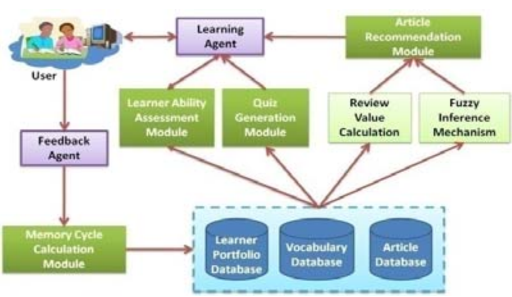

Fig. 1. Architecture of the Personalized English Vocabulary Learning System

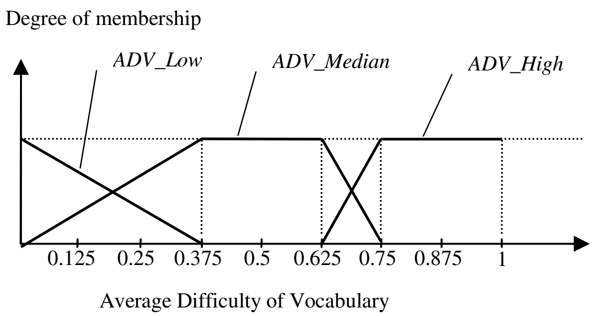

Fig. 2. Membership functions of feature variable ADV

paper set the difficulty of vocabulary test question equivalent to the difficulty of a word which is set according to the elementary, intermediate, and high-intermediate levels of GEPT.

Article Recommendation Module - uses fuzzy inference to find the suitable article difficulty level for a learner and uses Review Values to compute in an article the percentage of vocabulary a learner should review, and combines both to form the article suitability formulae for computing the suitable level of articles for the learner. The fuzzy inference mechanism consists of six layers, the Feature Vector Layer, Input Linguistic Layer, Input Term Layer, Rules Layer, Output Term Layer, and Output Linguistic Layer [12]. Figure 2 depicts the membership functions of feature variable Average Difficulty of Vocabulary, the ADV. When recommending an article to a learner the system rates not only its suitability but also its volume of vocabulary that the learner has to review. An article has a higher Review Value for a learner if it contains more vocabulary that the learner needs to review. Recommendation of articles to a learner is based on the suitability of the articles for the learner. Computation of the suitability of an article uses both the Document Fitness for Learner and the Review Values.

Quiz Generation Module - generates quizzes on both words that are newly learned and words that require reviews to help a learner remember vocabulary. These two kinds of words constitute a quiz with, normally, 10 questions for a learner after an article has being read. The ratio between the kinds of words is adjustable according to the learning status of the learner.

Memory Cycle Calculation Module - adjusts the memory cycles of both the newly learned words and review-required words tested in a quiz according to the correctness of answers to the questions in a quiz. Under intensive reading circumstance, learned words, which do not appear in a quiz might also help in figuring out the meaning of words in either the quiz or the article context. This paper therefore argues that memory cycles of these words should also be updated implicitly and accordingly to reflect a learner's remembrance of them. To summarize, update of memory cycles of learned words considers three factors: (1) implicit impacts from answers of questions, which do not test on learned words in a quiz, (2) the distances in a sentence between learned words and both new words and words requiring reviews, which are test by the questions in a quiz, and (3) explicit impacts from answers of questions, which test on learned words in a quiz.

3 Conclusion

In Taiwan, there are many researches on how to improve the study of English. This paper describes a unique approach that harnesses both fuzzy logic theory and memory cycle adjusting policy, to enhance personalized English learning based on the intensive reading proposition. The Learner Ability Assessment Module predicts the English vocabulary ability of a first time learner by using the Computerized Adaptive Testing approach and creates the learner's profile, which is then subsequently updated by the Memory Cycle Calculation Module. The Article Recommendation Module uses fuzzy inference and item response theory to find a suitable article for a learner, the Quiz Generation Module generates a quiz for the learner by picking from the read article those words that the learner is supposed to learn at his/her level, and based on the result of quizzes, the Memory Cycle Calculation Module then calculates memory cycles of every kind of vocabularies of a learner and updates the accordingly. With intensive reading of articles recommended by this approach, a learner learns new words quickly and reviews learned words implicitly as well, and by which the vocabulary ability of the learner improves efficiently. The prototype has been built and several experiments have being conducted currently.

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A Web-Based System for Visualizing and Analyzing Interaction Structure in Online Collaborative Learning

Yonggu Wang and Feiyue Qiu

College of Education Science and Technology, Zhejiang University of Technology, China
wyglxj@yahoo.com.cn, qfy@zjut.edu.cn

Abstract. Social network analysis is one of effective methods and techniques to analyze the interactions in online collaborative learning. This paper introduces our researches in which a web-based system visualizing and analyzing interactions in online collaborative learning was developed. Firstly, the function model, user interface and ar0063hitecture of the system are presented. Then, Three key steps and technologies in the implementation of the system are described. Lastly, we presented the case study in which the system is used to analyze and visualize the structures of interaction network in the collaborative learning. The case study proved that the system can visualize the socio-gram of the interaction network in different view, and can calculate the structures' indexes of the interaction interwork.

Keywords: Social Network Analysis, Interaction Network Structure, Online Collaborative Learning.

1 Introduction

Many researchers have verified that social network analysis (SNA) is an effective method and technique to analyze interactions in online collaborative learning [1]. In these researches, learners often participate in learning activities on such collaborative supported learning systems as bulletin board system (BBS), Moodle, Blackboard Learning System and so on. These online collaborative supported systems have no functions of collecting, visualizing and analyzing interaction relationships of learners. In this case, researchers must spend much time on collecting millions of records about interaction relationships, and then apply tools of SNA to analyze patterns of learners' interaction, such as UCINet, Pajek, InFlow etc. Many researches have demonstrated that, there are two main disadvantages in the above procedures of data analyzing [2][3]. Firstly, one collaborative learning experiment will generate millions of notes, online messages and emails. Researchers will spend much time on collecting and analyzing them, and pay less their attention to the data analyzing. Secondly, learners and tutors can not immediately detect their interactions in their collaborative learning activities, can not reflect and adjust their collaborative behaviors without the results of interaction analyzing. Therefore, to improve the performance of online collaborative learning, there are a great need to design and develop an online tool for visualizing and analyzing social networks in online collaborative learning.

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The rest of this paper is structured as follows. Next section introduces the main methods and technologies of this research, including social network analysis, GraphXML and Java universal Network/Graph Framework (JUNG). Then, the third section presents the design and implementation of the system for visualizing and analyzing the structure of interactions network in online collaborative learning. The fourth section present a case study which was performed in the systems developed in the third section. The paper finishes with a brief discussion that includes the benefits and limitations of the system and our ideas of further work.

2 Literature Review

2.1 Social Network Analysis

Just as a computer network is a set of machines connected by a set of cables, a social network is a set of people connected by a set of socially-meaningful relationships, such as friend, co-working or information exchange [3]. The notation of social networks and the methods of social network analysis have attracted considerable interest from both of fields of information and learning science [4].

By methods and techniques of social network analysis, researchers can study how information flows through network ties, how people acquire information and resources, and how cleavages and coalitions operate [5]. Many collaborative learning researchers have utilized many measurement index of social network analysis to evaluate online collaborative learning, such as in-degree, out-degree, betweenness, density, cliques, network position and so on [6][7]. In addition, many researchers have devoted themselves to develop visualizing and analyzing interaction relationships in virtual learning communities. For example, Commetrix which was developed by IKM Research lab at Technology University of Berlin is an excellent software framework for dynamic network visualization and analysis [8][9]. But unfortunately, the software is not based web, which means that learners and their tutors can not reckon and assess their interactions in online collaborative supported learning systems by themselves.

2.2 GraphXML

GraphXML is a graph description language in XML. The goal of GraphXML is to provide a general interchange format for graph drawing and visualization systems, and to connect those systems to other applications [10]. The generality and rich features of XML make it possible to define an interchange format that not only supports the pure, mathematical description of a graph, but also the needs of information visualization applications that use graph–based data structures [11]. The following code segment shows the simplest possible use of GraphXML that describes a graph with two nodes and a simple edge.

This example shows the basic style of a graph description in GraphXML. It greatly resembles the way HTML documents are written, albeit using different tags. The first line is required in all XML files. The second line identifies the file's type. Finally, the

```
1    <?xml version="1.0"?>
2    <!DOCTYPE GraphXML SYSTEM "file:GraphXML.dtd">
3    <GraphXML>
4      <graph>
5        <node name="first"/>
6        <node name="second"/>
7        <edge source="first" target="second"/>
8      </graph>
9    </GraphXML>
```

Fig. 1. The Format of a GraphXML File

third and the last lines enclose the real content of the files, much like the <html> tag that precedes and closes a well–formed HTML file. The real content begins with line number 4, which defines a full graph. We delineate graph definitions with the <graph> tag so that a file can contain several graph definitions. The body of the graph description is quite straightforward: two nodes and a connecting edge are defined.

2.3 Java Universal Network/Graph Framework (JUNG)

The Java Universal Network/Graph (JUNG) Framework is a free, open-source software library that provides a common and extendible language for the manipulation, analysis, and visualization of data that can be represented as a graph or network [12]. It is written in the Java programming language, allowing JUNG-based applications to make use of the extensive built-in capabilities of the Java Application Programming Interface (API), as well as those of other existing third-party Java libraries. JUNG is a java Object-oriented programming library which implements three key interdependent technologies, including graph theory, social network analysis and social network data mining. Graphs, nodes and edges between two edges are basic elements in three technologies, and are represented different level object or interfaces. JUNG provides a built-in mechanism, the UserData class, for annotating graph elements with data. This mechanism is particularly useful for handling data which can describe and represent the characteristics of graph elements.

JUNG provides three kinds of network algorithms. The First is ranking algorithms, which assign values to each vertex (or edge) according to a set of criteria that reflect structural properties of the network. These criteria are generally intended to measure the “influence”, “authority”, or “centrality” of a given vertex/edge. The second is clustering algorithms, which is used to find out collections of objects that are all similar to each other in some way. The Last are the algorithms of topologies, paths, and flows, which perform operations on (and calculate properties of) graphs that relate to the graph’s topology (that is, the structures and substructures formed by the ways that the vertices are linked together by edges)[12].

JUNG provides mechanisms for visualizing socio-graphs which require three kinds of visualization component. The first is a Layout, which takes a graph and determines the location at which each of its vertices will be drawn. The second is a Swing component, which provides a drawing area upon which the data is rendered. The third is a renderer, which takes the data provided by the Layout and paints the vertices and edges into the provided component.

3 System Design and Implementation

This section presents the methods and techniques of the system design and development. The design of this system is under the guilds of an interaction structure analysis theory framework [13], so we leave out two phases (requirement and system analysis) in the system development cycle, which is illustrated in Fig.2. In the design of the system, we focused on three development task, including system function model designing, user interface model designing and system architecture designing. In the system implementation, we applied three key technologies to implement the system design model which is produced in the design phase. In the last phase, we assessed the functions and usability of the system, found out the problems, then modified them.

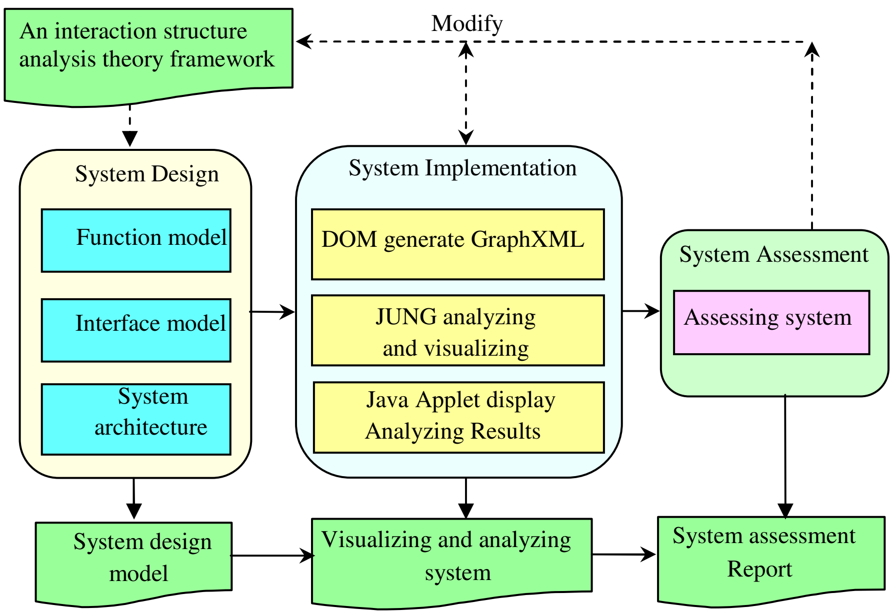

Fig. 2. The development process of the system

3.1 Function Model Design

The function model of the system is based the collaborative learning activities in which learners, lecturers and tutors participate. There are four kinds of collaborative learning activities which facilitate the achievement of learning goals, including learning resource sharing, asynchronous communication and discussion, online synchronous conversation, learning fruits co-creating and exhibiting. Based on the behaviors of collaboration and contents of interaction relationship, the interaction relationships

Table 1. The corresponding relation between learning activity, learning behaviors and interaction relationship

Learning activity	Collaborative Learning behaviors	Interaction Relationship
Learning resource sharing	Browse or download the resource document	Cognition interaction
	Collect as my favorite	Focused interesting interaction
	Recommend to my friends	
	Comment on the resource document	Emotion interaction
Asynchronous communication and discussion	Post knowledge-based notes	Cognition interaction
	Post coordinating and facilitating notes	Coordination interaction
	Post emotional notes	Emotion interaction
online Synchronous conversation	Greet, bless, chat	Emotion interaction
	Supervise and urge his/her partners	Coordination interaction
	Coordinate the conflicts among his/her partners	
	Ask for or provide help to solve problems in learning	Cognition interaction
Learning Fruits co-creating and exhibiting	Browse or download the learning fruits document	Cognition interaction
	Update and synthesize group learning fruits	co-creating interaction
	Comment on learning fruits	Emotion interaction

are divided into five types of interaction relationships, such as cognition, emotion, coordination, focused interesting, and co-creating [13]. The corresponding relation between learning activity, behaviors and interaction are illustrated in the table 1.

Different types of interactions generate unique and special effectiveness for different level of learning goals. For example, cognition interaction help learner comprehend knowledge points and apply them to solve a probem in certain subject, emotion interactions create a friendly learning atmosphere which will facilate learners dovote themselves into their collaborative learning activities, coordination interaction help learners establish and maintain positive relationships with their partners, and then increase their social responsibility and social awareness. Therefore, the system must have the function of analyzing different types of interactions relationship.

3.2 Interface Design

In this research, we found that, the interface of a visualizing and analyzing software must meet with three principles: 1) users can easily set analyzing conditions; 2) the results of visualization is so clear and succinct that users can draw conclusions based on them; 3) users can easily operate and transform the elements of visualizing graph. Two examples of interface design are represented below:

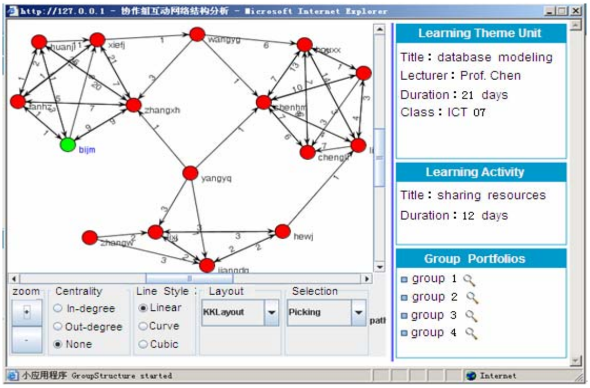

Fig. 3. The results of visualizing and analyzing interaction structure

In the above example, the interface shows the results of visualizing and analyzing, inllustrated in Fig.3. The right frame of the window shows the attributes of the learning theme unit, the learning activity and groups. The top section of the left frame in the window shows the socio-gram and some indexes' values of the interaction structure, in which the nodes denote the learner or tutor in online collaborative learning, the edge between two nodes denotes the interaction relationship, and the value attached an edge denotes the number of interaction between the two learners. In addition, the lower section of the left frame lists the interface components by which users can change the layout, size, style, values of indexes, and style of dragging.

3.3 System Architectures

The flows of the data processing in one system are the basis for its architecture deployment. The flows of data processing include four main steps below: 1) after accepting the operations of users, the user interface converts these operations into the HTTP requests, and then sends these requests to PHP programs on the web server. 2) PHP programs process the HTTP requests sent by IE browser, then extract the datum of interaction relationship which are represented as adjacent matrices from MySQL databases. 3) Data conversion module converts adjacent matrices into GraphXML files, and save them under a folder on the web server. 4) the Java Applet embed the web page in IE browser sends requests of users' operation to the Java Beans coded by JUNG libraries on the web server, which process the requests of Java Applet, then fetches results of analyzing and visualizing from JUNG java beans, lastly displays the results of analyzing and visualizing interaction structure on the IE browser.

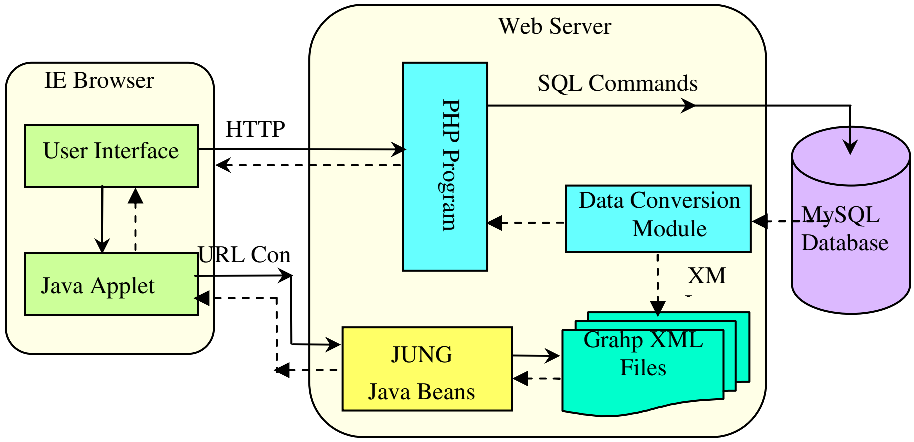

Fig. 4. The flows of data processing in the system

3.4 System Implementation

There are three key steps and technologies in the process of system implementation, including XML DOM generating GrahXML file, JUNG calculating the properties of interaction structure and Java Applet visualizing the results of analyzing and visualizing.

XML DOM generating GrahXML files. The XML DOM (Document Object Model) defines a standard way for accessing, generating and manipulating XML documents. In this research, we used PHP scripts to generate the GraphXML files with the DOM API.

JUNG calculating the properties of interaction structure. In sum, there are three key steps in the procedure of JUNG analyzing the properties of interaction structure. Firstly, the JUNG programs read the GraphXML files representing the interaction network. Then, the programs calculate the structure properties of the interaction network with structure analyzing algorithms. Lastly, the JUNG programs display the socio-gram and the values of indexes.

Java Applet visualizing the results of analyzing and visualizing. To show the result of analyzing, the Java applet embedded in the web page need to call the GraphXML files representing the interaction network. Considering multiple users can analyzing their interaction network at the same time, the Java applet must load the different GraphXMl file based on their user identification.

4 Case Study

In this section, we present the results of the analysis in the learning resource sharing and asynchronous discussion activity. Firstly, we show the interaction network structure of six groups and their tutors with the socio-gram, and list the indexes' values of the interaction network structure in the learning resource sharing activity. Then, we analyze and visualize the interaction network structure of group 6 in the asynchronous discussion activity.

The socio-gram in the Fig. 5 is the visualization of the interaction structure in the learning resource sharing activity. Based the socio-gram, we can qualitatively analyze the structure of the interaction network. We easily get the characteristics of the structure of the interaction network. Firstly, the whole network of the class has fragile connectivity, but every group has relative stronger connectivity. Secondly, at least one member of every group has interaction relationships with members of other groups, and takes on the role of broker of information. Thirdly, the tutor (wangyg) of the class also takes on the role of broker of information, which means some learning resources of groups are come from the tutor. Lastly, both group 5 and group6 have higher density than those of other groups, which means the two groups have more cohesions.

The indexes in table 2 describe the whole properties of the interaction network. The densities of the Group 5 and Group6 are relative higher than other groups in the

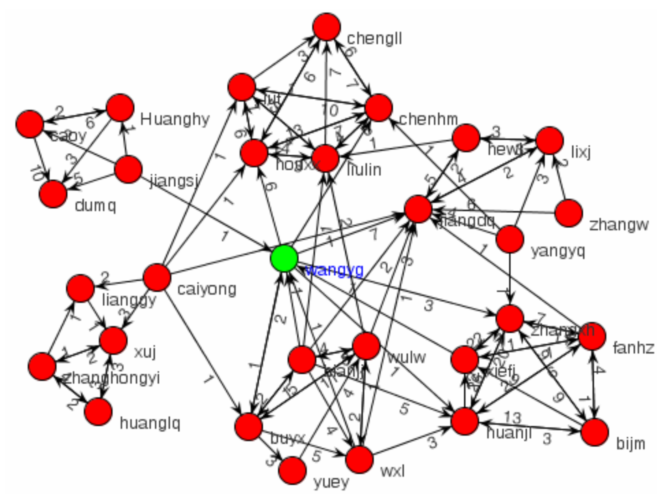

Fig. 5. The socio-gram of six groups and their tutors visualized by the system

Table 2. Indexes of structure of interaction network

	G 1	G2	G 3	G 4	G5
Out-Degree centralization	0.558	0.804	0.074	0.246	0.183
In-Degree centralization	0.583	0.98	0.748	0.437	0.352
Density	2.5	2.41	1.7	1.1	5.55

class, which means that the members of the two groups exchange more learning resource than those of other groups. On the other hand, we fund that the out-degree and in-degree centralization of group2 is very large, which means that the interaction between members of groups are centralized in only few members.

In addition, we can visualize and analyze the structure of interaction network of a single group. For example, Fig. 6 shows the socio-gram of Group 5 in asynchronous discussion learning activity. The socio-gram is complete graph, which means any member of the groups has interaction relationship with the other members of the group. The socio-gram shows the frequency of interaction of the two members from the number attached the edge between two nodes.

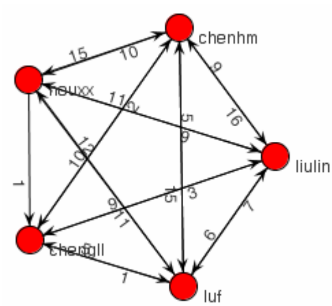

Fig. 6. The socio-gram of the Group 5 in the asynchronous discussion

The centrality indexes can indicates who has the most influence in the collaborative learning activities. Table 3 shows the out-degree and in-degree of every member in the asynchronous discussion learning activities. We can easily find that Chenhm have the most influence in the learning activities, on the contrary, Chengll has the least influence in the learning activity.

Table 3. The centrality indexes of the interaction network structure of group 5

	Out-degree	In-degree
Chenhm	56	26
Chengll	6	25
Liulin	35	32
Houxx	28	38
Luf	29	33

5 Conclusion and Future Work

Social network analysis is an effective method and technique to analyze and assess the interaction in online collaborative learning. Researcher or teachers can qualitatively analyze the interaction network structure with the socio-gram visualized by SNA tools. On the other hand, they can analyze the properties of the interaction network with the indexes of structure. In this paper, we presented a web-based system which can analyze and visualize the interaction network structure in the learning activities. In the design of the system, there are four key development procedures, including designing function model, designing the user interface and deploying the architecture. And there three key steps in the implementation of the system, such as XML DOM generating GraphXML, JUNG calculating the properties of interaction structure and Java Applet showing the results of visualizing and analyzing. Finally, we introduced a case study in which the system is used to analyze and visualize the structures of interaction network in the collaborative learning, and we found that the system can visualize the socio-gram of the interaction network in different view, and can analyze the structures' indexes of the interaction interwork. In the future, we will devote ourselves to analyze the whole structure properties of interaction network, such as the cohesion and the network position spatial of the interaction network.

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Articles as Assignments – Modalities and Experiences of Wikipedia Use in University Courses

Klaus Wannemacher

HIS Hochschul-Informations-System GmbH, Goseriede 9, 30159 Hannover, Germany
wannemacher@his.de

Abstract. In spite of perceived quality deficits, Wikipedia is a popular information resource among students. Instructors increasingly take advantage of the positive student attitude through actively integrating Wikipedia as a learning tool into university courses. The contribution raises the question if Wikipedia assignments in university courses are suited to make complex research, editing and bibliographic processes through which scholarship is produced transparent to students and to effectively improve their research and writing skills.

Keywords: Web-Based Learning, Constructivist Learning, Information Competency, Media Literacy, Teaching Strategies, Web 2.0, Wikipedia.

1 A Web 2.0 Project Challenges University Instructors

Since its launch in 2001, Wikipedia has become one of the most popular websites and Web 2.0 applications worldwide. As of early 2009, the English-language Wikipedia edition contained more than 2.8 million articles, while the German-language version, the second largest among more than 260 language editions, comprises more than 900,000 articles [21]. While the use of open contents and encyclopaedic information as provided by Wikipedia has caused considerable problems within the academic community (e.g. the plagiarism problem and the declining use of reliable published sources in term papers), Wikipedia has become one of the most frequented information resources on the web after Google and Ebay [9][13]. In this context, Wikipedia has facilitated and contributed to processes of self-contained learning and knowledge construction inside of universities as well and instructors increasingly apply the online encyclopaedia as a tool for teaching.

While academic research on Wikipedia has focused on aspects such as collaborative processes of knowledge construction and knowledge management, community building and coordination processes, Wikipedia as a lexical semantic resource, or quality management procedures [5][10][12][16][27], little research has been done on the potentials of utilising Wikipedia within university teaching. In a short field report Bendel [1] describes course experiences with editing Wikipedia articles using tiered forms of online collaboration. Ebner [3] analyses Wikipedia use in courses pointing out the decisive difference between voluntary communities of practice driven by corresponding interests and 'forced' learning communities using Wikipedia at

M. Spaniol et al. (Eds.): ICWL 2009, LNCS 5686, pp. 434–443, 2009.

universities. Hodel & Haber [8] outline different phases of student experience occurring during a course using Wikipedia assignments from enthusiasm through outrage to disillusionment. Konieczny [11] describes a range of approved Wikipedia assignment forms that have successfully been applied at US universities. Linking to these earlier analyses, this contribution aggregates and interprets different types of Wikipedia in teaching projects and their contributions to the online encyclopaedia based upon a comprehensive list provided by Wikipedia's English-language edition of some 97 Wikipedia university projects that have been carried out worldwide since 2002.

The contribution strives for a synthesis of course practice experiences made at universities in recent years. However, the data available so far derived from incidental course documentations do *not* allow for a quantitative in-depth analysis of aspects such as the changing attitudes of students toward the online encyclopaedia, the adequacy of Wikipedia use for courses of different disciplines, the impact and didactical sustainability of different courses and assignment forms, the learning processes and learning outcomes within courses using Wikipedia compared to courses with conventional assignment forms, or the resulting workload of instructors. Only a future empirical survey with a standardised set of parameters based on a group of Wikipedia using courses as well as on lecturer and student polls will be adequate to provide for a more detailed analysis of course practice under use of Wikipedia.

1.1 Professional Scepticism against Wikipedia

Within the university context Wikipedia is received with scepticism due to perceived conflicts with fundamental scientific standards. A serious value of Wikipedia is regularly negated for reasons of scientific validity: "According to the criterion of scholarly standards, Wikipedia is citable on no account since authorship is not verifiable, and therefore an authentification of information is impossible." [7]. Despite the scientific validity problem and the focus of Wikipedia authors on a language "understandable to the educated layman", the online encyclopaedia, however, claims to exclusively compile material that is verifiable [22].

For reasons of verification, Wikipedia authors are committed to use "reliable, third-party published sources with a reputation for fact-checking and accuracy". Wikipedia's verifiability directive states that "editors should provide a reliable source for quotations and for any material that is challenged or likely to be challenged, or the material may be removed." [22]. The quality of Wikipedia content is to be guaranteed through an internal peer review process of the Wikipedia community. US publicist James Surowiecki coined the concept of the "Wisdom of Crowds" [18] for such mechanisms of distributed quality management. Wikipedia's quality management approaches cover a multi-stage procedure for evaluating selected articles as well as a system of discussion pages for encyclopaedic entries. In contrast to academic standards, however, Wikipedia's quality management procedures predominantly apply not until the publication has already taken place [8].

Aspects such as the comparatively high professional quality of many Wikipedia contributions even in comparison to established print encyclopaedias [19][6], and the opportunity of using encyclopaedic content free of charge account for the specific appeal of the digital encyclopaedia for students. Students value Wikipedia as a useful tool for their research and paperwriting duties. An information resource that was initiated as a participatory community project increasingly enters genuinely academic spheres and unintentionally influences the teaching and learning practice at universities.

2 Emergence and Objective of Wikipedia in Teaching Projects

The participatory character that has been regarded as a weakness of Wikipedia pertaining to its scientific validity by some is perceived as a specific didactic quality by others. In particular, the strong appreciation of students for Wikipedia prefigures the online encyclopaedia's adequacy as a teaching tool. Prolific ways of integrating and actively using Wikipedia for teaching have been applied at universities worldwide. In different subject-related contexts, instructors use Wikipedia under the didactic proposition of an active self-organisation of knowledge as the basis for communicating different educational objectives such as strengthening the competency to assess and differentiate between diverse source materials. Instructors apply Wikipedia in courses as the basis for work assignments such as the training of a good narrative style, the discussion and review of specific encyclopaedic entries, or the complete or partial revision of selected articles as a precondition for performance records. The following overview over manifold forms of using Wikipedia in courses that have been conceived so far exemplifies advantages and problems of this specific form of Web 2.0 oriented course work and provides ample reference for instructors on how to design similar courses.

2.1 Basic and Advanced Forms of Use

Many universities have applied demanding forms of Wikipedia use. The application of the online encyclopaedia in teaching at universities has partly been self-reported and documented by instructors. Since such a documentation solely exists within the English Wikipedia edition, consideration will be given to the comprehensive data provided there. The English Wikipedia's "school and university projects" page specifies some 97 genuine Wikipedia projects at international universities between 2002 and 2009 (reference date: February 20, 2009), among them projects at the Ivy League universities of Columbia, Cornell, Dartmouth, Harvard and Yale, and at the Massachusetts Institute of Technology. The "school and university projects" pages of Wikipedia editions in other languages and an Internet search for further Wikipedia in teaching projects proves that the actual amount of projects is much larger, though.

2.2 Statistical Data on Wikipedia in Teaching Projects

The possibilities of a quantitative analysis of the data on the "school and university projects" page are restricted to some general facts since the depth of information provided on different teaching projects varies strongly. The following analysis begins with a short quantitative analysis of general data and then predominantly focuses on a qualitative analysis of the differing approaches and experiences made within those 97 projects. The Wikipedia in teaching projects documented on the English "school and university projects" page came from 19 different countries (several additional projects documented on the Catalan, Czech, French, Polish, Russian, and Slovene Wikipedia editions could not be taken into account). As far as precise information is provided, a majority of 65 courses came from US universities, colleges or business schools. 8 projects originated from higher education institutions in Canada, 5 projects came from Hong Kong. Another 20 projects were carried out in 16 other countries such as Australia, Germany, or the United Kingdom.

The projects came from diverse fields of study with a strong focus on the humanities. Exactly half of the international projects (49 of 97 projects) had a background in the humanities such as English writing, history, or cultural studies classes. Perhaps, text-oriented course types and hermeneutic working methods common among humanities' scholars encourage and facilitate the utilisation of Wikipedia within collaborative text editing assignments. 15 projects came from engineering science, 11 projects came from natural science, 11 from social science, and 4 from medical science. 3 projects came from economic science, 2 from agricultural science, and 1 from law. Some instructors gave no indication on the course topic. Many courses had an interdisciplinary character.

2.3 Constant Increase in Wikipedia Projects

A strong increase in projects using Wikipedia in teaching has taken place since the first mentioned courses. 4 of the documented projects took place between 2001 and 2003 (the "school and university projects" page has not been set up before the year 2003, though). 24 projects occurred between 2004 and 2006. 63 projects took place between 2007 and 2009 so far which adds up to considerably more than a duplication of projects compared to the previous period of time. Some projects were counted several times if taking place in subsequent time periods.

The nature of course work with Wikipedia was diverse. 88 of 97 projects involved the editing of existing encyclopaedic entries or the creation of new entries. 8 projects explicitly applied collaborative article editing. 5 of the projects even envisaged improving articles with the end goal of nominating them within Wikipedia's quality assessment process for "Good Article" or "Featured Article" status (e.g. Jon Beasley-Murray's successful Spanish class "Murder, Madness, and Mayhem" at the University of British Columbia, spring 2008). 5 projects asked for participating in an appropriate "WikiProject", a collection of pages devoted to the management of a specific topic or family of topics within Wikipedia, or the participation in a Wikipedia portal on a specific issue. Only 5 projects expressly mentioned a focus on analysing Wikipedia as a Web 2.0 application and as an open content community. At least 8 projects involved work in language versions of Wikipedia other than English.

2.4 Objective of Wikipedia Projects

The objectives of the documented Wikipedia courses were manifold. Besides the ostensible aims of enhancing the students' state of knowledge, particular emphasis was put on propaedeutic aims such as making the research, editing and bibliographic processes transparent. Many instructors wanted to help students develop an awareness of the contested nature of knowledge production, as well as of the required rigour and balance in writing encyclopaedic articles. Work on Wikipedia articles requires the consideration of different perspectives on a subject (Wikipedia's "neutral point of view" principle), e.g. in creating a balanced version of a nation's history. The neutral point of view is fostered by the frequently chosen collaborative form of student work as well. A theoretical analysis of Wikipedia as a network phenomenon, of quality measurement issues, or Wikipedia-related aspects of collaborative knowledge management was intended by other instructors.

Moreover, instructors wanted to give students an opportunity to experience collaborative writing and online publication, and wanted to foster their research skills. Motivational aspects played a major role in these courses since writing for a very large audience was strongly motivating many students and made them put more work into the project than they would have otherwise. Even though 6 of 97 instructors explicitly report that a majority of students enjoyed those projects, others relate mixed results. Some students regularly abandoned Wikipedia assignments and preferred to do conventional writing assignments instead. With regard to the collaboration aspect, many instructors wanted students to learn from the advice of their own teammates as well as to benefit from the editorial feedback of regular Wikipedia contributors. Since regular "Wikipedians" often visited course articles, students got to experience feedback in many forms from someone else than the instructor. Instructors requested students to take all feedback into account.

A specific objective of some courses consisted in overcoming language barriers. Occasionally, students were allowed to work on different language editions of Wikipedia such as the Catalan, French, Italian, Russian or Spanish Wikipedia edition. This was practised if a course was offered by universities from different countries cooperatively and if a cooperation between students from different universities was demanded (e.g. the cooperation between Barcelona University and Washington University in St. Louis within the WikiProject "History and Archaeology of Central Asia" in fall 2007). Students were expected to write or edit articles in either language edition. Discussion still took place on the English-language version of each article.

The accomplishment of these versatile course objectives has been assessed by instructors through means of having course discussions on the student experiences during course work, through supervising the development of Wikipedia "article history" and "article discussion" pages related to articles given as course assignments or through examining 'final' Wikipedia article versions after course work had ended.

3 Course Practice and Assignments

The use of Wikipedia in university courses requires a thorough and extensive preparation by instructors. The following synthesis of course experiences derived from the courses depicted on the "school and university projects" page provides instructors with advice for Wikipedia-related courses of their own as well as with proposals for accompanying research on Wikipedia use in university teaching.

In the courses depicted on the "school and university projects" page, several work packages were regularly carried out for the preparation of courses. Many instructors created an introduction page for their students at Wikipedia. This page could serve to introduce students to the wiki system, to ensure that they are working within the bounds of Wikipedia guidelines, and to precisely advise them what they can do. Since article work on Wikipedia currently requires students to publish their texts under a free license, some instructors requested their students to submit a letter to them stating that they understand the implications of licensing their own work, e.g. making their texts reusable by the general public. Students that did not want to publish their texts could submit them at the discretion of the instructor.

Providing a choice of texts that should be produced or revised by students was another central preparatory task. Wikipedia provides a broad range of "open task" pages with assignment proposals for instructors that are accessible primarily through Wikipedia's "community portal" [23]. Additional support can be mobilised through a specific Wikipedia project. Instructors can contact the English Wikipedia's "WikiProject Classroom Coordination". More than 40 volunteers offer assistance for course conception and carrying out specific course tasks on this project page.

3.1 Teaching Methods

The Wikipedia courses documented on the "school and university projects" page exhibit a wide range of assignments forms. Some courses start with an overview on the development of encyclopaedias from ancient world's Gaius Plinius Secundus until digital encyclopaedias under consultation of research literature. Regularly, students are initially introduced to the Wikipedia site and to Wikipedia norms and conventions. Instructors let students familiarise with Wikipedia as a knowledge resource and as a community. Among common 'warm-up assignments' are having students create a Wikipedia login of their own, letting them make some basic edits to an individual user page, and letting them practise article editing in the "sandbox", a so-called Wikipedia "namespace" page designed for testing and experimentation with the wiki syntax before actual article work is carried out. Additional warm-up exercises consist of editing text, and adding a citation to an existing article, or letting students do categorisation tasks.

A typical multi-level course layout as realised in the course "Introduction to Interdisciplinary Studies" by Scott Alberts at Truman State University, Missouri, in fall 2007 took advantage of so-called "Wiki Labs" [24]. The course scheduled 7 wiki-labs out of which 4 were required and 3 were voluntary labs. The labs consisted of the assignments 0) finding a short path from article A to article B, 1) setting up a user page, 2) getting busy, 3) working collaboratively on an article, 4) writing a real article, and 5) and 6) making an article "good", joining a project, or working on special pages. The class applied "contract grading" in which students signed a contract stating exactly what grade they would like to receive and how much work they would like to do. Carrying out labs 4 to 6 was required to receive an upper grade.

3.2 Forms of Assignment

The most commonly applied Wikipedia assignments is letting students edit articles. Students are asked to research, and critique an existing article with a focus on readability and accuracy, work up drafts of the proposed revision, and edit the article drawing on appropriate research literature. After having incorporated changes into the Wikipedia articles, students should observe and discuss in class subsequent comments and edits other users make. Different options of article work apply such as choosing and expanding so-called "stub-articles", i.e. short Wikipedia articles in need of expansion. Sometimes students individually work on separate articles, sometimes they collaborate on different segments of an article in groups. Students were also asked to add references to articles under use of at least one primary source, one encyclopaedic source, and one scholarly book or article (e.g. in a "Roman Civilization" class at Northwestern University in the spring term 2007).

Instead of rewriting articles students can also contribute preapproved new articles or sub-articles ("stubs") related to the course issue. While the initial revision of existing articles occasionally takes place offline under use of a stand-alone course wiki, prior to submitting the students' work to Wikipedia, new articles are usually generated in the students' "userspace". After the draft is completed, it can be transferred over to Wikipedia "mainspace". In most cases, article editing assignments in courses optionally substituted writing a course paper or a final research paper. Sometimes a final class project consists of revising an article on the central course topic.

3.3 Feedback, Documentation and Analysis

The feedback process regularly involves instructors reviewing article revisions as well as regular Wikipedians providing critique. While some instructors regard the additional feedback of regular Wikipedians to their students and the experience of collaboratively editing texts as useful, others prefer to work on a stand-alone wiki to avoid external intervention [2][4][15]. Another form of making use of the collaboration opportunities of Wikipedia includes students evaluating and commenting on other student-written articles on their discussion pages (e.g. within a "Downstream Processing" class, Cornell University, fall 2006). After article drafts underwent peer review and the editing process, they are submitted to Wikipedia mainspace. Some instructors called students to present the articles they have been working on within individual or within group presentations.

Many courses included a documentation and analysis of Wikipedia course work. This documentation started before the beginning of a term with the creation of an assignment list on the instructor's user page. The assignment list later turns to a list of completed articles. Other forms of documenting Wikipedia use in courses include using a course blog or a general blog [14]. Occasionally, students had to document the research and changes made to Wikipedia articles as well as the experiences of having their articles edited in a course-accompanying report or an essay. Some instructors asked students to complete a brief follow-up online questionnaire about the course.

4 Advantages and Disadvantages of Wikipedia Use

Even though Wikipedia was initially not meant to be used for teaching, and Wikipedia founder Jimmy Wales strongly advises students against relying upon Wikipedia as authoritative [28], the use of the collaborative encyclopaedia offers several advantages such as the didactically activating method, the propaedeutic training of properly using scholarly secondary sources, intensive text work and the collaborative training of writing competencies as well as learning outcomes relevant to examinations. The "school and university projects" page additionally promotes as advantages of this course form that many "of these projects have resulted in both advancing the student's knowledge and useful content being added to Wikipedia. An advantage of this over regular homework is that the student is dealing with a real world situation, which is not only more educational but also makes it more interesting ('the world gets to see my work'), probably resulting in increased dedication. Besides, it will give the students a chance to collaborate on course notes and papers, and their effort might remain online for reference." [20]

The advantages and disadvantages of writing articles on Wikipedia have regularly been discussed within Wikipedia courses. The evaluations of many instructors on the "school and university projects" page seem to back some of the claims made in the above paragraph but learning outcome research on courses using Wikipedia remains a desideratum to date. As a positive result of the active integration of Wikipedia in teaching, in connection with a 2006 Yale University course on "History of Modern Science in Society", teaching assistant Sage Ross emphasised multiple positive effects of Wikipedia courses such as

- the increased student motivation due to the perspective of an (anonymous) online publication and the further use of their texts
- a better understanding of the proper use of scholarly secondary information sources
- as well as an advancement of the argumentation and negotiation culture (to which the Wikipedia "neutral point of view" principle substantially contributes).

Ross concluded that Wikipedia were „a very convenient forum for giving and receiving feedback from classmates, which can dramatically improve the quality of student writing" [17]. Students benefited from the aspect of an improved writing competency the same way that the encyclopaedic tool being used does since the collaborative editing of texts leads to a considerable increase in the quality of Wikipedia entries.

4.1 Critical Experiences

The quality of student contributions to Wikipedia in a course context varies strongly. Sporadically, Wikipedia in teaching projects have produced minor response by students who were adding only little information to the pages involved. Some classes resulted in downright failure, perhaps due to the unfamiliarity with Wikipedia and a lack in pedagogical guidance. A "Global Economics" course from Marshall University, Huntington, West Virginia, caused extensive disputes between the Wikipedia community, the instructor and the students in early 2008. Of some 70 articles that were newly created within this course, only seven survived in anything like their original form. About half of the articles were swiftly deleted, others were merged, or redirected since community guidelines had not sufficiently been considered [25]. Frustrating course experiences such as these can be avoided through a thorough preparation of courses and through calling on students to make themselves familiar with the basic structures of community-driven Web 2.0 course tools such as Wikipedia.

Therefore, a decisive disadvantage of Wikipedia use for teaching is associated with the workload of instructors. Instructors have to invest a significant amount of time in enabling students to contribute to wikis and in the extensive review of student contributions to Wikipedia articles. This additional work relates to the necessity of revising errors in the students' wiki syntax. Further disadvantages consist in lacking digital competencies of students, unwanted external interventions by regular Wikipedians, the impermanence and changeability of texts, or in students producing inappropriate texts that have to be revised and "cleaned up". Difficulties can also occur in developing appropriate criteria for grading the students' intellectual output. Therefore, innovative forms of grading, another important aspect of Wikipedia use in teaching, are applied such as evaluating students not only on their written contributions, but also on the effectiveness of their editing [26].

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Enhancing the Ability of Creative Expression and Intercultural Understanding through Visual Story

Wahju Agung Widjajanto, Michael Lund, and Heidi Schelhowe

Digital Media in Education Research Group, University of Bremen, Bibliothekstraße 1,
28359 Bremen, Germany
{wahju,mlund,schelhow}@tzi.de

Abstract. In our web-based platform "*Wayang* Authoring" children with different cultural backgrounds can create and share stories, and make experiences in culturally different storytelling. The idea of *Wayang* Authoring is based on the Indonesian ancient art form *Wayang*. The research question focuses on if and how the design of our system can support children to enhance understanding of story grammar, creative storytelling and self-expression as well as help to share cultural diversity. In this article the *Wayang* Authoring platform and its background is presented.

Keywords: *wayang*, storytelling, story grammar, authoring tool, web-based application.

1 Introduction

Throughout the world puppet show is a popular form of entertainment. Sometimes it is an ancient heritage, a reminder of an age long past; sometimes a medium for contemporary artist's experiments with shape, color and movement. For centuries it has been used to relate myth and legend and enact simple traditional farces. Now, as well as undergoing a tremendous revival as entertainment for both adults and children, it is becoming more and more widely used in education and also in therapy.

In our project *Wayang* Authoring we want to use the web to revive traditional storytelling with puppets. We aim at educational use of virtual storytelling. Sharing an interesting and challenging application and practicing intercultural exchange young people all around the world can gain media literacy. We want to enable children to express themselves in creating own stories and to share them with others.

Virtual worlds cannot substitute the rich experience of performing with real puppets and a face-to-face audience. But we want to ponder the potentials of Web design and usage for the field. New possibilities may arise from a worldwide availability and from intercultural exchange of local knowledge on storytelling. Web software can alleviate own construction and design activities. The popularity of client-side scripting allows extended functionality and new kind of interactivity in web applications. The Web offers amazing communication and cooperation possibilities all over the world, especially with the rise of social networking sites and the semantic web.

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The idea of *Wayang* Authoring is based on the Indonesian ancient art form *Wayang*. We will explain more about it in the third and fourth chapter. *Wayang* as a traditional art form offers a space and power to be explored. The second chapter will portray about the field of storytelling and story grammar. In our project that is described in the sixth chapter we combine the tradition of *Wayang* story telling with digital media in order to create a new type of performance possibility without obstructing the role of the original art itself. *Wayang* Authoring is designed as a multimedia web-based application for children to create stories and to build a virtual community of storytellers. At the end we will refer to Jenkins notion of media literacy in order to reflect on how these competences could be encountered by *Wayang* Authoring. We estimate the understanding of audio-visual codes become a major literacy factor in a media defined society because it changes the way to read and write.

2 Storytelling and Story Grammar

Storytelling is an ancient art form where experiences, events and actions are conveyed in words, images and sounds. This art form is traditionally an oral performance with an interactive relation between storyteller and audience. The storyteller uses often a set of incidents or fragments of plots that are mixed and composed in an improvised manner [1].

Storytelling and the development of media influenced each another alternately, and each new media established a new kind of storytelling. With Digital Media as a major media nowadays several new kinds of storytelling are created, such as text adventure, interactive fiction, role-plays and games with story elements. In an interactive story the user becomes the protagonist (the main and active character of a story) travelling through a universe of possibilities [2].

The process of story creation follows typically certain rules. In order to analyze the structure of stories it is possible to divide a story into small units. By several rearrangements it becomes obvious that only some arrangements of those units are acceptable as a story. Some narratologists like Gerald Prince developed formal models of narration according to detected patterns and roles [3]. According to Gerald Prince the content unit of stories is the event. The 'stative event' of an agent (a character) describes a situation or status of mind, for example "Robert is happy". The active event expresses an activity, a movement, an action of an agent or a change, for example "Robert reads a book". With this unit it is possible to detect causalities, to analyze chains of actions and to comprehend reasons of an agent. Even though *Wayang* Authoring is meant to support the intuitive handling of the grammar of a story, some basic aspects of the Gerald Prince's model and David Herman's approach [4] inspired our concept. The tool enables starting with the creation of several story units that later can be combined and rearranged.

3 A Living Shadow Theater Tradition

Puppets are shadow, hands, dolls, figures and figurines. *Wayang* is the general word to many kinds of traditional theatre in Java, Bali, and some other parts of Indonesia

Fig. 1. Example of *wayang* puppets

and Southeast Asia, both puppet theatre and actor's theatre. *Wayang* is an ancient form of storytelling that originated from the Indonesian island of Java. Communities that enliven the *wayang* tradition exist meanwhile all around the world.

Wayang kulit consists of two words, *wayang* and *kulit*. *Wayang* is a Javanese word meaning shadow or ghost, *kulit* means leather, and added together it can be translated as 'shadow from leather'. The *wayang kulit* is a two-dimensional puppet, made of buffalo or goat leather; like paper dolls, but with arms that swivel (see Figure 1). A *wayang kulit* puppet is a representation of mainly human characters and the physical world. Every part of the puppets' design has symbolic significance.

The rich visual tradition of Javanese shadow theatre adapted a huge range of archetypical images. Often the visual appearance is an abstraction of a human characteristic, a specific emotion or behavior. The shadow enhances the evocative character [5],[6]. The figures become alive. The psychologist Fritz Heler created an animation movie, where abstract shapes like triangles and dots become actors. The audience gives those shapes intentions, wishes and personality. Heler suggests that the ability to create and understand stories is a human ability that helps us to get orientation in the social world and to understand others. Stories are fields for experiments, to try out relations and to develop empathy [7].

4 Story Structure in *Wayang* Tradition

Like in other theatrical traditions the dramatic narration consists of characters, situations, contexts, locations and time. The stage for the puppets is the empty blank screen, which is on one hand undetermined by any situation, context, and time but on the other hand is the possibility for every possible imagination of the world. The puppets carry the context and establish a situation in space and time as soon as it appears on the screen.

Pictorial moments in the performance are moments or segments during which the puppets are stuck in a banana trunk, and either not moved at all, or only their arms are moved as 'they' speak. At this moment the visual movement stops and the screen becomes like a picture and the puppeteer begins the dialog. When the dialog is over the puppeteer may take the puppets from the position and start to move immediately.

This interplay of movements and visual-oral dialog is one of the narrative techniques of *wayang* that is extended by a technique, which Jan Mrázek called *wayang*-montage. The partial representation of a movement for example does not only make this impression of a continuing movement, but rather what happens mentally in between the shown parts [8].

If we pin down the structure of a *wayang* performance we could differentiate it also like Gerald Prince in units of 'events active', such as movements and units of 'events stative' or when the situation change to a pictorial mode. In this pictorial mode dialogs are acted out which are also 'event active'. The specific character of *wayang* seems to be the combination of visual language, dialog and a language of movements. These movements are represented in partial representations that seem to be similar to montage in movies. The aesthetic category of the decision to show a partial aspect is 'what needs to be seen'. This category is also used by the visual construction of puppets and also the wholeness of a character can be comprehended as a combination of its several appearances that are performed during the narration.

5 Related Works

Technology offers an opportunity to support and facilitate collaboration in many respects [9]. YouTube [10] and Flickr [11] are well known platforms for sharing content; videos and pictures respectively. In these systems users can share contents and find inspirational ideas by looking at other user's creations. However, these are not platforms that support the creation of content. Users need other tools to produce pictures or videos. And also none of them addresses children as a special target group.

Animation tools like Flash [12] are popular and very good tools to make designs, animations, and user interfaces across all browsers and platforms. But this tool is too complex for children to create an animation.

TellStory is a web application system that supports collaborative construction of stories [13], but this application supports only text based story. KidPad is a collaborative visual based story authoring tool for children. KidPad provides drawing, typing and hyperlinking in a large two-dimensional zoomable screenspace. By these functionalities children can create stories by scenes and link them together in a virtual space [14]. However, TellStory and KidPad do not support the aspect of story grammars.

6 *Wayang* Authoring

Building *Wayang* Authoring we learned from existing approaches and decided to use digital media and the Web not only to support children to create visual stories either individually or collaboratively with others, but at the same time helping children to understand 'the grammar of stories' in general and in a specific culture by composing and arranging stories according to a story line.

6.1 *Wayang* Authoring as a Visual Story Tool

Wayang Authoring is designed as a tool to compose a visual based story than a text based story because visual element is especially important for young children, who often think in iconic, visual forms, as well as for poor readers who rely more on visualization of thoughts to scaffold memory skills [15].

In cooperation with drama teachers we got indication that the *wayang* images in *Wayang* Authoring can support children for allowing themselves to enter the imagination. The aesthetic power of images foster children to get involved in this play and the pictures get a live. Like a picture book in drama education can be used to create an own story, our tool can be used to explore the world of a story and to prepare for the play-making with the physical puppets with a processing storyboard. The design of the shapes and the need to choose an emotional style for the acting picture limits the repertoire of fixed dramatic solutions to the substance and fosters concentration that is often dispersed by every day (multi)media. The handling of cultural artifacts support the ability to understand different cultural codes and we hope that it supports also the curiosity to learn more about the culture behind these artifacts. This can enhance intercultural empathy.

6.2 Elements of the Prototype

Wayang Authoring is composed of three elements: the imagination building element, the creative working element and the social interaction element (see Figure 2.). At first element children can get an idea or an inspiration from the tutorial or from stories that already exist, are stored and shared by other users. The second element enables a child as a member of the *Wayang* Authoring community can compose a story, save, replay and perform it. Then in the third element they can share stories, give comments and rank other children's stories. This process is supporting children to get friends and to connect with friends in the context of the social network.

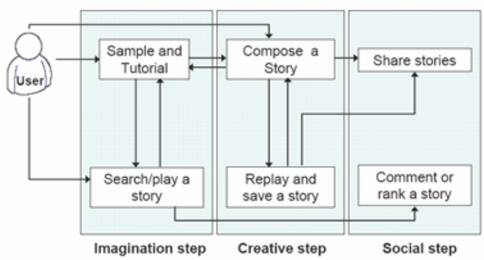

Fig. 2. Basic elements of *Wayang* Authoring

6.3 Tool Features

The main features of *Wayang* Authoring are:

1. **Composing a story**. This feature is the main function of this tool. The user composes a story by clicking and dragging objects, moving it and assigning some properties to the object. A story can be recorded and replayed. Dialog boxes (text) can be added to the story to make the story more attractive. The web-based GUI of this "composing a story" is shown in Figure 3.
2. **Playing a story**. The user can play a story by choosing it from a list of stories. Color and black/white can be selected when a story is played.

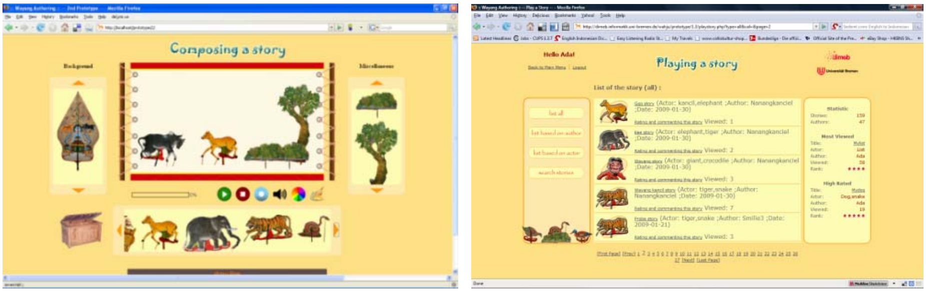

Fig. 3. Screenshot of *Wayang* Authoring's prototype

3. **Rearrange story's sequence**. A story can be composed from some units of small story. This functionality enables children to compose a story from others story and rearrange the sequence to get the different meaning of the whole story.
4. **Sharing a story**. This feature enables the users to share their stories or to decide not to share.
5. **Rating and commenting**. Users can rate a story and comment a story.
6. **Grouping**. This tool is supposed to create groups of stories based on the main actor of the story. Each user can become involved in several groups.

6.4 How the User Can Define Movements

The web-based GUI for composing a story allows for recording the movements of objects. The user can define the movement of an object using the dragging capability of that object. Direction and speed of the movement are automatically recorded, so that the user can record all movements very easily without defining a time line. A start/end point of the object's movement can be fixed. An object can be flipped using a context-menu.

6.5 Individual and Collaborative Stories

In *Wayang* Authoring user can create an individual but also a collaborative story. The tool "individual and collaborative stories" enables to combine different individual, maybe partial stories (that are in the "shared" modus) to one whole story. The user can also change the sequence of a story to get a different meaning out of the story. By this way, the children can learn about 'story grammar'. Story grammar as a topic of education fosters the ability to detect a meaning by reading. This function is illustrated in Figure 4.

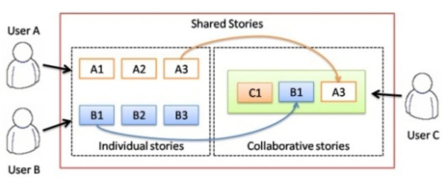

Fig. 4. Individual and collaborative stories

We refer to Jan Mrázek that by ordering the partial representation should be related together so that an action or a story can be built up – for the creator knows what is important to know and how things fit together. Children will learn to produce and understand causal and temporal structured plots that are organized around a variety of themes and involve certain character. Besides that, they also develop the necessary skills to recognize when a plot makes sense or not

6.6 Organizing Story in a Visual Symbolic Way

We consider implementing a functionality to show or play a story using symbols and story lines. Position or distance between actors can be identified from the story line. Each actor will be symbolized as a color line. Activities of the actors, such as dialog, flipping, changing mood, etc, are showed using small symbols.

This functionality is showed on the Figure 5. At this story an elephant comes to the stage in a happy mood, indicated by green circle. But a tiger then appears in a bad condition, indicated by black circle. The tiger and the elephant start a dialog, symbolized by bubble symbol. A triangle symbol is indicated that the actors turned back (flip) from the current position. At the end the tiger becomes happy; the black circle on the red line is changed to be a green circle and then he is rolling down, symbolized by a circular arrow.

We believe this story line model will help children to enhance imagination and creativity because to symbolize is an act of construction and a very important act of thinking. Language and script are the basic symbol set of our culture. In order to progress in mental processes the subjects are supposed to translate experiences into symbolic representations. Symbolization is in this view the basic of invention and creation of ideas. Symbols are not only surrogates of the objects of this world; they are also a vehicle that helps to picture and understand the real objects.

Helping children's symbolic imagination development and making available a place to exercise it, narrative activities in general and storytelling in particular, prepare the way for abstract thought development and deeper mental processes [16].

This is related with *wayang* tradition, as a living traditional art form hold on a set of symbolic shapes that can be used as a medium to express one self and to evoke fantasy and imagery, to communicate with the own inner world and with others.

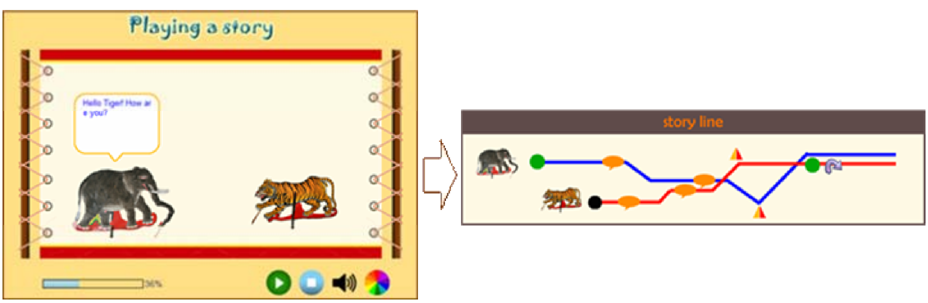

Fig. 5. A Story in a visual symbolic presentation

7 Discussion and Evaluation

Wayang Authoring is designed as a web-based authoring tool for visualizing storytelling with *wayang* figures via Internet. As it is interactive, users who author the stories can specify the behavior of each object. *Wayang* Authoring is also a choice to create a community and a social network of *wayang* storytellers to share and to exchange their stories.

According to Hanry Jenkins paper which he published with the Mc Arthur Foundation in 2005 more than one-half of all teens in the US have created media content, and roughly one third of teens that use the Internet have shared content they produced. He summarized that (and other) trends under the term “participatory culture” that should become the center of modern media education [17].

Wayang Authoring in its concept is supposed to serve three kinds of requirements described by Hanry Jenkins supporting the emergence of a “participatory culture” [17]:

1. **Affiliation** - through creating a user profile and joining a group centered on its favorite character.
2. **Expression** - through creating a new story with the authoring tool.
3. **Collaboration** - through rating and commenting other children’s stories. Also through rearranging or recomposing a story list.

If these objectives among the others can be realized by children enacting with *Wayang* Authoring will be the subject of empirical research we want to conduct in future.

In our tool the movable pictures of the *wayang* tradition provide a context for the expression of feelings and ideas. Using these images to create own stories children of diverse cultural background can adapt aesthetic ideas not only of the Indonesian culture. The structures that afford to build stories by small units enable them to explore, clarify and transform the feelings and ideas also by reflection.

We conducted a first workshop with eight children with different cultural background at the International School Bremen. This workshop has been focused on usability and functionality of the prototype. We collected feedbacks from the participants regarding their opinion about the prototype.

Most of them had no difficulties to use the prototype without guidance. They enjoyed using this tool and could compose a story, playing and sharing it.

On a second workshop we focused on the story grammar. We gave the kids four parts of a story to be arranged. They discussed and arranged some logic sequences of that story reasonably. Some of them added a bridging part that enables to create either a story with a completely different meaning or in an order that was not reasonable before. It seems that they followed an unconscious comprehension of story grammar that enables them to arrange or complete unconnected parts of a story according narrative logic.

In the last step we asked them to create a story by our tool. They all succeeded to create a story, although some of them had an uneasiness to split a story into some small units during composing a story. They preferred to compose one story as a whole instead of arranging it from some small units. The challenge would be to make the grammar of stories more explicit and to support the playful and improvisational character of the story creation of *Wayang* Authoring.

By two testing stages we observed that children were fascinated by the aesthetic of the Indonesian art form implemented in this software. Two of the children felt motivated to tell spontaneously about their own cultural background. During a longer term school project about Indonesian shadow theatre a student got the chance to perform several small testing observed by a literature and drama teacher. The teacher stated that the visual appearance and the implemented work flow were first uncommon but easy to handle for most of the children. But this not accustomed work flow and appearance evoke a greater curiosity just to try and play unrestricted. The implemented workflow especially is not too complex but support them to perform or play with the tool with suspense. The imagination seems to be more stimulated. Some participants created small stories with only one or two figures and they seem to be identified with them. According to the drama teacher it looks like that this tool supports to re-enact social conflicts in a save atmosphere and to tryout creative solutions. Additionally the teacher told that she noticed that some children with poor language skills speak meanwhile the use the tool. Often it seemed that in this context their language is better.

Beside the main story creation stage this tool offers also a stage where all participants of the community are visualized on a globe. We will evaluate this feature in the next testing stage. Initially we show this stage to two children. They seem to understand this feature by "oh now we can see our friends on the globe". We hope that the visualization support curiosity to try to communicate with children from other cultures, and that the focus on visual story telling ease to do this.

8 Summary and Future Work

In summary, we propose a new approach to design story authoring that is intended to enhance children's ability to tell stories and to express themselves as well as help to share cultural diversity. This media concept is in accordance with main aspects of the ancient art form of *wayang* and combines the world of digital media activities with a traditional art context. We want to explore further that the visual and kinesthetic approach of giving the children a basic idea of story grammar can enhance the ability of creative expression. We believe and are determined to explore further how *Wayang* Authoring can contribute to intercultural communication, social knowledge, media literacy, empowerment and contribution in a participatory culture.

We will conduct other workshop to observe the participants, whether they really engage in composing a story using this prototype, whether they use the online community feature, and pay attention to other users by commenting or ranking a story.

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A Meta-model Describing the Development Process of Mobile Learning

Anna Wingkvist and Morgan Ericsson

School of Mathematics and Systems Engineering,
Växjö University, Växjö, Sweden
{anna.wingkvist,morgan.ericsson}@vxu.se

Abstract. This paper presents a meta-model to describe the development process of mobile learning initiatives. These initiatives are often small scale trials that are not integrated in the intended setting, but carried out outside of the setting. This results in sustainability issues, i.e., problems to integrate the results of the initiative as learning aids. In order to address the sustainability issues, and in turn help to understand the scaling process, a meta-model is introduced. This meta-model divides the development into four areas of concern, and the life cycle of any mobile learning initiative into four stages. The meta-model was developed by analyzing and describing how a podcasting initiative was developed, and is currently being evaluated as a tool to both describe and evaluate mobile learning initiatives. The meta-model was developed based on a mobile learning initiative, but the meta-model itself is extendible to other forms of technology-enhanced learning.

Keywords: development process, meta-model, mobile learning.

1 Introduction

The focus on mobile learning has increased during recent years, and there is a rapid growth in research initiatives aimed at developing and deploying portable technologies to support learning [11]. Mobile learning has grown from a minor research interest to a set of significant activities in schools, workplaces, museums, cities, and rural areas around the world [8]. The current mobile and wireless technologies have reached a level of maturity and ability that makes it possible to support a wide variety of learning activities.

A concern is that few of the mobile learning initiatives (i.e., and the information system to follow) are ever developed into actual learning aids that are in wide use [3]. In order for mobile learning to prove its educational and scientific value, more research initiatives need to develop into substantial results and tools that are used in massive scale. Naismith and Corlett [6] present a retrospective where they look back on the papers published at mLearn 2002 to 2005, and they find several challenges related to development and integration of mobile learning. In this paper we summarize issues similar to those found by Naismith and Corlett as sustainability issues – cases where the mobile learning simply does not fit the intended use and environment.

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To address the challenges of mobile learning, this paper introduces a meta-model that describes the evolution and development accordingly. There are many uses for such a model, for example to guide the development of new initiatives, or to evaluate and understand existing initiatives. The meta-model introduced in this paper describes the life cycle of a mobile learning initiative using four stages, and each of these stages are divided into four areas of concern. The meta-model consists of a sequential life cycle where each stage is iterative. The sequential evolution is referred to as scaling and the iterative process as the process of reaching equilibrium. Scaling and equilibrium are important in order to reach sustainability.

This paper uses the term mobile learning initiative to describe any research activity that aims to investigate the use of mobile learning and develop new ways to learn using portable technology. The rest of the paper is organized as follows. Section 2 introduced the meta-model and all its parts. Section 3 presents an analysis of a podcast initiative using the meta-model. Related work is presented in Section 4 and the paper is concluded by a brief discussion of the findings and future research efforts in Section 5.

2 A Meta-model for Development of Mobile Learning

In this section we introduce the meta-model and describe it. The model is divided into four stages that show the life cycle of a mobile learning initiative, and each stage can be illustrated using four areas of concern. These areas of concern describe what can be seen as the different problem areas that must be addressed. During the life cycle, different areas of concern will be in focus, but each stage in the life cycle is made up from all the areas, even if they are not in focus. In this section, we begin by addressing the four stages, and then the four areas of concern. We then give an account of the concept of focus, and how it is used in the meta-model.

2.1 The Stages of the Life Cycle

The life cycle of a mobile learning initiative consists of four stages: Idea, Trial, Project, and Release. Depending on the outcome and the scope, it can be limited to fewer stages, but in the general case, we assume that the aim of an initiative is a release in a "production" environment. Figure 1 shows the four stages of the life cycle.

Everything starts with an idea. This idea can be seen as a vague notion of what, who, and how. How can a mobile device be used as a learning aid, how should learning be transformed onto this mobile device, who is the intended target group, and so on. The major role of the Idea stage is to establish these concepts, and to verify them. Valid questions are whether the mobile technology is available and accessible, if the learning activities can be transferred, will the learning appeal to the intended target group, and so on. In essence, the Idea

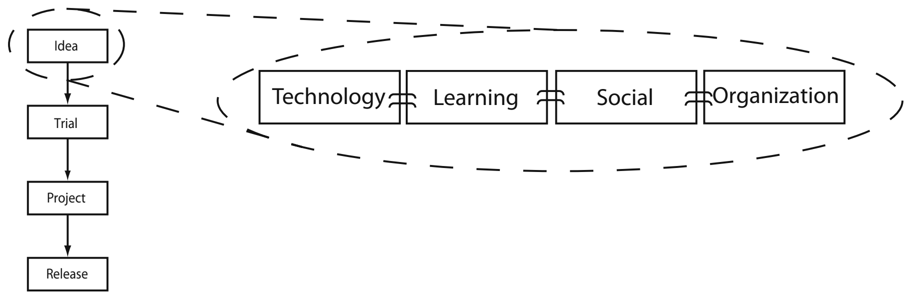

Fig. 1. The Areas of Concern

stage is about forming an understanding. The product of the Idea stage is a description of a trial, with specific variables to test.

The major role of the Trial stage is to determine whether or not a particular idea works in a specific setting. The Idea stage established a number of things, and the Trial stage is the first proper test of these. The Trial is carried out with a distinct user group, and the focus is on figuring out what works and what does not. One could for example measure how well the learning translates to the actual technology, or how well the learning works with respect to the intended target group. The output of the Trial stage is a description of a project with specific goals.

The Project stage is a more formalized and realistic extension of the Trial. A Project, in this context, is formally defined with stated prerequisites and a goal. Generally, a Project require more funding than an Idea and a Trial, and a project application could serve as the formal definition. The goal of the Project stage is still to understand if the idea works or not, but now in a setting that is much closer to the intended setting with a larger number of participants. Another important goal is to study how the participants interact within the Project, for example producers and consumers of learning. The outcome of the Project stage should be a description of how the idea should be integrated into a real setting, and how to be "released".

The Release stage occurs when the Project ends, and is the release of the outcome of the mobile learning initiative. This outcome is deployed as an actual "product".

The evolution that happens within the life cycle, here depicted in stages, is a sequential process. Once the Idea stage ends, the Trial stage begins. Within each stage, there is an iterative process, where things are tested, verified, and rejected or accepted. It is possible to reject an entire stage and return to a previous one.

Two important processes happen during the life cycle: *scaling* and *equilibrium*. Scaling is the process of moving from one stage to the next. For example, using the findings from the trial to prepare a project is the scaling from Trial to Project stage. Finding equilibrium is the process of reaching balance within a stage. Equilibrium is simply a state that is reached when everything "works". The goal of the iterative process within a stage is to reach equilibrium. Scaling and equilibrium are discussed in more detail in Section 2.4.

2.2 The Areas of Concern

The important evolution that occurs throughout the development process happens within the stages. A mobile learning initiative can be defined by four areas of concern: Technology, Learning, Social, and Organization. These areas, as depicted by Figure 1, are interconnected and of equal importance. A change to one of them will affect the others and you cannot ignore any of them.

The Technology area involves all the technology needed to realize the initiative. This includes hardware and software, for example portable devices, servers, blogs, etc. Technology is often perceived as the focal point and the limiting force of any mobile learning initiative, and it is an important part. This is the reason why technology forms an area of concern.

The second area of concern is Learning. It is separated from technology since the technology is there only to facilitate the learning, not to be the center of it. In a similar manner, its focus is only on the translation of the learning activity to the mobile device in this area, and not on the producers and consumers of learning. Since to enhance and/or improve learning is the goal of any mobile learning initiative, it is important enough to constitute its own area: How will people learn, what are the important characteristics of the learning, how can a learning concept be transformed into something suitable, etc.

The third area of concern is the Social. This includes the people involved in the process, and the parts they play. Learning happens in a social context, and even if it takes place via mobile devices, there will be social interplay. In order to create a working mobile learning initiative, it is very important to understand how the people involved "work" and what they want.

The fourth and final area of concern is the Organization. Any mobile learning initiative is controlled by rules and regulations; this is the main function of the organization, as well as to provide support and infrastructure, practical and pecuniary. Any mobile learning initiative will exist within one or more organizational settings, each complete with agendas, policies, politics, etc. In order to work within these organizations it is vital to understand the setting well enough to be able, at least, to coexist with it.

The four areas together form a complete picture of the mobile learning initiative. However, this complete picture can be difficult to grasp. To deal with this difficulty, the model uses *focus*.

2.3 Focus

During the evolution, focus will shift from area to area, and can at times include more than one area. Hence, focus means that the primary objective at the time is to improve the area(s) addressed. The other areas are still present and affect and are affected by the work on the area that is focused. Imagine a camera lens that zooms in on different parts of a situation. The focus will move from one area to another, revisit, and discover if the situation has changed. In using the metaphor of a camera, the process of mediation between the areas is easier to understand. One area might be the focus of attention at a particular time, but

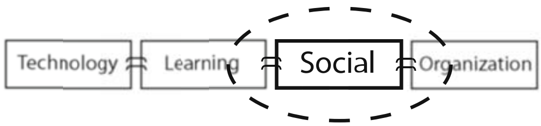

Fig. 2. Focus on the Social Area of Concern

the other areas are still present in the peripheral vision. The part that is focused dominate the view, but events outside of the focus can still affect the part being focused and vice versa. However, it is possible to see all four areas at the same time, but only by sacrificing the level of resolution. Figure 2 illustrates focus on the Social area of concern.

Each stage of the evolution is an iterative process. Changes to something will spill over and affect other things, and this process will continue until the stage reaches a state where it can be considered "good enough". The focus shows where the initial changes are most likely to happen, and what is to be formed and shaped during the stage. For example, in the Idea stage there are generally vague ideas about the "how", "what", and "who" of the initiative and a focus on technology. The main objective is to evaluate and evolve the technology to a point where it supports the goal of the initiative. This in turn means that technology will shape and be shaped by the other areas of concern.

In each stage of evolution, one or a few areas dominate the focus. Applying focus is a way to handle the increasing complexity of the mobile learning initiative systematically. A simple way to describe the areas of concern is that each area adds an additional layer of complexity, i.e., factors to consider. The more complex the initiative gets, the more of these there are to worry about. In the first two stages, the focus is on getting the technology to work and dealing with the learning task or activity. Once these two are on acceptable levels, the later stages focus on introducing producers and consumers i.e., the social aspects of the learning activity, as well as the organizations that benefit and support the initiative, financially and with other means. These generally are far more complex. Figure 3 depicts this change in focus during the evolution.

The purpose of focus in the meta-model can be seen as threefold. First, focus is used to break down a complex whole into smaller parts that are easier to grasp and work with. Second, focus allows a working order, where the area focused is the development target. It is not the only part being developed, but it will be the main objective. The third purpose is that focus illustrates the evolution process by indicating where the main difficulty and complexities will happen in the initiative.

2.4 Scalability, Sustainability, and Equilibrium

As discussed in Section 2.1, scaling is the process that happens between stages in the life cycle. Scalability refers to an initiative's ability to scale. Sustainability is a measure of how well an initiative solves the problem it was intended to solve and how well it fits the setting. An initiative that results in a learning aid that is

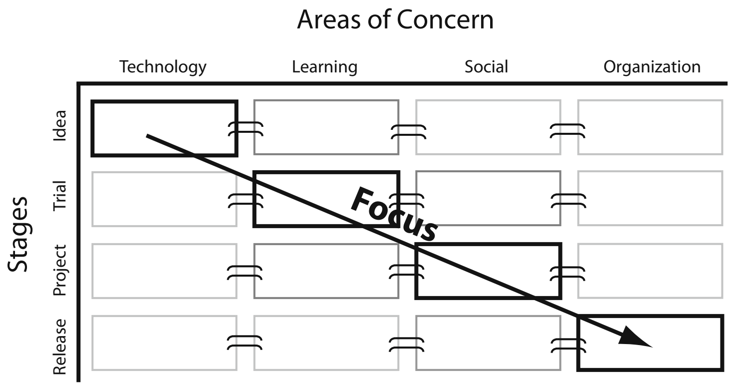

Fig. 3. Focus Changes Throughout the Life Cycle of an Initiative

in use will have a high sustainability while an initiative with low sustainability will fail. Scalability affects the sustainability.

Scalability can be considered as the initiative's ability to grow. This expansion, in respect to all the four areas of concern, should be able to handle different types and groups of users and organizations with everything that are entailed for the areas of concern. There will always be a point at which scalability stops making sense, i.e., a largest rational organization it can scale to or a "market" that can be "controlled". Using this description, scalability can be defined as the ability to reach sustainability at an evolutionary stage. The more stages at which it reaches sustainability, the more scalable the initiative is. In this respect, saying that a mobile learning initiative is scaled to Project stage simply means that it found balance at the stages of Idea, Trial, and Project. The components (areas of concern) were in unison with each other at each stage.

The four areas of concern will have different importance, i.e., focus, during the evolution of a mobile learning initiative. But, it is still important that the areas get at least noticed and are in balance at each stage. When a change is done, it will affect the other areas in different ways, and these may need to react and adjust. When there is no longer a need for reaction and adjustment, the stage has reached a state of equilibrium. If a change causes too much friction between the areas it might result in that equilibrium can never be reached, and the change needs to be reverted. This can be difficult and even impossible and if balance is not reached the initiative might "self-destruct".

Within each stage, equilibrium signifies a stable state. Reaching that state means that everything is working as planned. A stage that is working as planned is as important during the evolution as it is during the release stage. If the stage is not in equilibrium, it is hard to measure and extract any meaningful data, which are needed in order to be able to evolve to the next stage.

For example, assume that an initiative is in the Trial stage, in which the stage is not in equilibrium due to a poor software solution. The poor software will reflect badly on the trial and it will be hard to separate the poor response that was due to the software from eventual poor response to the idea of the initiative.

3 Using the Meta-model to Analyze a Podcasting Initiative

This section presents a Podcasting initiative and an analysis of the initiative using the meta-model. In this case we use the meta-model to understand an existing initiative to illustrate how it can be used. As a visiting researcher at COSC, the COmputer SCience Research Group, during fall of 2006 and spring 2007, the first author of this paper had first hand experience of the initiative and it is further described by Bell et al. [2], and Wingkvist and Alexander [14]. The aim of the Podcast initiative was to provide supplementary material to the courses held at Canterbury University, Christchurch, New Zealand, that students could use while doing other activities.

The Podcast initiative started with the idea to use podcasts to supplement the learning experience, which a student is expected to have in a course. The initiators used the technology themselves and imagined that students would find it beneficial to be able to refresh course work while doing other activities, such as household chores, exercising, and commuting to and from university. The idea grew into a number of concerns, especially about the technology. Was it in wide use, would the students accept it, and so on. In order to answer these concerns, and to better understand the setting, a questionnaire was given to students. The questionnaire measured several concerns, for example access to digital audio players and podcast usage. The result provided enough understanding to reach equilibrium at the Idea stage and helped formulate a Trial. As suggested by the model, the major focus was on technology.

In order to test the idea, podcasts were used as part of two Computer Science courses, with approximately 400 students. The two courses offered weekly podcasts with varying contents, ranging from reading aloud from the text book to interviews styled sessions with other lectures, business people or researchers in the field of Computer Science. In order to measure how well received the podcasts were, a questionnaire and other data sources, such as download logs were used. Similar to the model, the focus was on how learning could best be facilitated by podcasts, i.e., how to structure the content.

The Trial targeted Computer Science students and the initiators created the podcasts. In order to test how viable the idea really was, other disciplines, students and lecturers had to take part. The Project stage extended the initiative to cover courses within four other disciplines, i.e., Japanese, Economics, Music, and Educational studies, with about 400 students. This was done in order to test how well podcasts suited other disciplines, for example languages studies, and how easy it was for lecturers to produce and publish podcasts. It was also important to test how well the technology was accepted by both lectures and students that did not study Computer Science. While part of the focus was still on Learning, the major focus was on the Social issues of how producers and consumers of learning work together using podcasts.

This analysis shows that the meta-model can be used to describe the project in terms of stages and focus. For a more detailed analysis of the podcasting initiative using the meta-model, see Wingkvist [13].

4 Related Work

Software development (SD) models are used to structure, plan, and control software development. There are a number of such models, and they can generally be divided into sequential, iterative, or a combination. The sequential methods are divided into separate phases, which are carried out in order. An iterative method is generally divided into smaller phases, and the full set of phases is iterated over. Examples of sequential models and iterative models are the waterfall model [7] and prototyping respectively [5].

Instructional design is the practice of creating instructional content and tools to help facilitate learning activities. ADDIE [1] is a generic and simplified instructional system development (ISD) model. The model is divided into five phases, Analyze, Design, Develop, Implement, and Evaluate. ADDIE is a sequential model where to outcome of the previous phase is the input of the next step.

The evolutionary life cycle model introduced in this paper shares many similarities with both SD and ISD models. A difference is that the model introduced in this paper exists on a meta-level, and SD and ISD models are used on a more pragmatic level and form the tool set used to deal with the areas of concern. For example, the Learning area of concern says nothing about how the learning should be designed and implemented, but rather that learning, technology and the other areas of concern are connected. Similarly, the model introduced in this paper models the evolution, but SD and ISD models can be used for each step of this evolution. This is similar to the Unified Process for software development [9], which consists of several phases, each with several iterations, and many of the phases have their own set of methods and models.

Several frameworks and meta-models that aim to aid and improve the development and understanding of mobile learning initiatives have been published. Many of these address only on one or a few aspects of mobile learning, and in this section the interest is only on frameworks and meta-models that intend to capture the entire development process.

Taylor [10] presents an evaluation framework for the MOBIlearn project that illustrates to some extent the evolution and the order in which different areas are in focus. She starts from a technological standpoint and continues with pedagogical considerations, and socio-pedagogical perspectives, while acknowledges the influence of the data counter flow. The ideas behind this framework resemble those of the meta-model presented in this paper, though only from an evaluation point of view.

Laouris and Eteokleous [4] make an attempt to create a systematically complete framework to define mobile learning. This framework is expressed using mathematical notation and use functions to describe relations and dependencies between elements, e.g., content, IT, learning environment. In terms of intent, this framework is similar to the meta-model, but uses a completely different approach to describe the elements and the development process.

Vavoula and Sharples [12] propose a framework built on holistic and systematic evaluation divided in three levels of granularity, i.e., micro, meso, and macro, to guide the data collection when designing, implementing, and deploying a mobile learning initiative. Thus, the requirements analysis persisted throughout the initiative's life cycle, and covered all three levels of analysis. They conclude that mixed methods are increasingly present in the design of evaluation activities for mobile learning. The core approach of continuously addressing granularity and employing strategic evaluation compare well to the view of stages and focus of the meta-model in this paper, but the pragmatic approach differ since the meta-model can provide a main focus for each development stage, as well as to what to evaluate.

5 Conclusions

In this paper we present a meta-model that is used to describe the life cycle and development of mobile learning. The meta-model can be used for example to guide new development efforts or to evaluate existing mobile learning initiatives. The paper further presents an analysis of an existing initiative using the meta-model.

The main contributions of this paper are the life cycle model and how it relates to the concepts of equilibrium, scalability, and sustainability. By linking the sequential evolution, i.e., the scaling of a system, and the iterative process within the stages, i.e., the process of reaching equilibrium, the sustainability of a mobile learning initiative can be defined as being able to scale to and reach equilibrium at the last stage of the life cycle. A sustainable system is a scalable system. Another important concept is focus and the way focus allows for targeting different areas of concern during the evolution. The metaphor of a camera lens makes it is easier to understand focus and how to deal with the complexity involved when undertaking a mobile learning initiative. This provide an intuitive notion of what happens during a stage, and how one should consider all areas of concern.

The meta-model is currently being used to evaluate and understand other technology-enhanced learning initiatives. We are interested in using it to study initiatives that do not use portable technologies to see how well the meta-model works in those cases. There is nothing in the meta-model that specifically ties it to mobile learning, so we believe that it is general enough to cover other forms of technology-enhanced learning as well. We are also interested in using the meta-model to guide the development of a new initiative for a more "hands-on" experience.

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A Web-Based Search Engine for Chinese Calligraphic Manuscript Images*

Yi Zhuang[1,2], Nan Jiang[3], and Haiyang Hu[1]

[1] College of Computer & Information Engineering, Zhejiang Gongshang University, P.R.China
[2] Zhejiang Provincial Key Laboratory of Information Network Technology, P.R.China
[3] Hangzhou No. 1 Hospital, P.R.China
zhuang@mail.zjgsu.edu.cn

Abstract. In this paper, we propose a novel framework for the web-based retrieval of Chinese calligraphic manuscript images which includes two main components: 1). A *Shape-Similarity*(SS)-based method which is to effectively support a retrieval over large Chinese calligraphic manuscript databases [19]. In this retrieval method, shapes of calligraphic characters are represented by their approximate contour points extracted from the character images; 2). To speed up the retrieval efficiency, we then propose a *Composite-Distance-Tree*(CD-Tree)-based high-dimensional indexing scheme for it. Comprehensive experiments are conducted to testify the effectiveness and efficiency of our proposed retrieval and indexing methods respectively.

1 Introduction

The large amount of Chinese calligraphic scripts (e.g., as shown in Fig. 1) in existence is a valuable part of the Chinese cultural heritage. Given a query calligraphic character, retrieving all the similar ones may help studying different written styles of the same character. However, the current approach is to use metadata or indices, which are created manually in a tedious, labor intensive and expensive process. This makes automatic approaches to searching and accessing this material very attractive. As we know, optical character recognition(*OCR*), which performs well on machine printed characters against clean backgrounds, can not be used to retrieve the Chinese scripts that are available through public libraries or Internet. Due to the following reasons, no effective techniques can support the retrieval of Chinese calligraphic characters written in different styles:

(1) *Deformation*: The same writer under different moods can generate different styles of the same character. Sometimes a character is deformed consciously for a better artistic effect.

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Fig. 1. Calligraphic character images with red seal marks as background

(2) *Complexity*: It has been estimated that an average character is composed of 12.71 strokes [1, 2] on average. The size of a stroke varies according to the total numbers of strokes composing the character, and the size of a stroke segment depends on the total number of segments composing the stroke.

(3) *Degradation*: Many historical calligraphic works have been degraded by nature changes.

Moreover, so far, there are no efficient techniques have been proposed to retrieve Chinese calligraphic characters when the size of character database is very large. In essence, the efficient retrieval of Chinese calligraphic characters directly relates to how to index them, which belongs to the category of high-dimensional data indexing. Although considerable research efforts have been done on the high-dimensional indexing issue [10], unfortunately, the existing high-dimensional indexing methods can not be directly applied to Chinese calligraphic characters due to their unique characteristics:

- The number of contour points extracted from each Chinese calligraphic character image is usually very large (i.e., above 150 dimension), conventional multi-dimensional indexing techniques, e.g., R-tree [11], can not readily be used to index them due to the "*curse of dimensionality*".
- The number of contour points of a character is different from each other owing to the shape's complexity. Many existing high-dimensional indexing schemes (e.g., R-tree [11], VA-file [13], etc.) are not suitable for indexing the Chinese calligraphic characters only because they can not well handle the high-dimensional query with variable dimensionalities.

In this paper, we address an efficient issue of retrieving Chinese calligraphic character based on a novel character retrieval method in our previous work [19], then we propose an high- dimensional indexing scheme based on a distance-tree, called CD-Tree, which is specifically designed for indexing the large Chinese calligraphic characters. With the aid of CD-Tree index, a k-nearest neighbor query of character Vq in high-dimensional spaces is transformed into a range query in the single dimensional space.

The primary contributions of this paper are as follows:

1. We propose a novel similarity-based retrieval method to effectively support the Chinese calligraphic characters retrieval.
2. We introduce a distance tree-based indexing method to facilitate the highly efficient Chinese calligraphic characters retrieval with variable dimensionalities.
3. An extensive performance study using the 12,000 isolated Chinese calligraphic character images is conducted to evaluate our approach.

The remainder of this paper is organized as follows. In Section 2, we provide background of our work. Then in Section 4, we review a *Shape-Similarity*(SS)-based retrieval method for Chinese calligraphic characters. In Section 5, a *Composite-Distance-Tree*(CD-Tree)-based high-dimensional indexing scheme is proposed to dramatically speed up the retrieval efficiency. In Section 6, we report the results of extensive experiments which are designed to evaluate the efficiency and effectiveness of the proposed approach. Finally, we conclude in Section 7.

2 Background

Numerous promising research works have been done on the handwriting recognition [5]. For instance, a word-matching technology is used to recognize George Washington's manuscripts [3], and the historical Hebrew manuscripts were identified in [4]. However, no published research work has been done successfully on Chinese calligraphic character retrieval because it differs from other languages by its enormous numbers and complex structure of ideographs. In [6] Shi et al. have shown a content-based retrieval method for antique books, however it is unknown how well this rigid visual similarity-based method works on the Chinese calligraphic characters retrieval with different styles of handwritings in different dynasties. Belongie et al. [8] have proposed an inspirational and similar approach to ours, yet it is much more complex at least for calligraphic character retrieval. Our earlier work includes applying the Projecting method [2] and the Earth Movers' Distance (EMD) method [9] to the Chinese calligraphic character retrieval. However, these two recognition techniques are too rigid to be applied to the retrieval process.

There is a long stream of research on solving the high-dimensional indexing problems [10]. Existing techniques can be divided into three main categories. The first category is based on data & space partitioning, hierarchical tree index structure, e.g., the R-tree [11] and its variants [12], etc. Although these methods generally perform well at low dimensionality, their performance deteriorates rapidly as dimensionality increases due to the "*dimensionality curse*" [10]. The second category is to represent original feature vectors using smaller, approximate representations, e.g., VA-file [13] and IQ-tree [14], etc. Although these methods accelerate the sequential scan by using data compression, they incur higher computational cost to decode the bit-string. The above two categories of indexing approaches, however, are only suitable for indexing the multi-dimensional data with the fixed dimensionality and does not fit for indexing the character features since almost every character has different number of contour points (dimensionalities). Therefore, the distance-based approach (e.g., NB-tree [15] and iDistance [16]) may be a promising scheme to indexing them since it does not heavily depend on the dimensionalities of the characters. NB-tree [15] is a single reference point-based scheme. The drawback of it is that NB-Tree can not significantly prune the search region and especially when the dimensionality is becoming large. iDistance [16] is proposed by selecting some reference points in order to further prune the search region and improve the query efficiency. However the query efficiency of iDistance largely relies on the results of data clustering and partitioning.

3 The Shape-Based Retrieval: *A Review*

One of the key problems in Chinese calligraphic characters retrieval is the matching of similar isolated character images. In this section, we review a shape-similarity(*SS*)-based retrieval method to perform a retrieval process, which was proposed in our previous work [19].

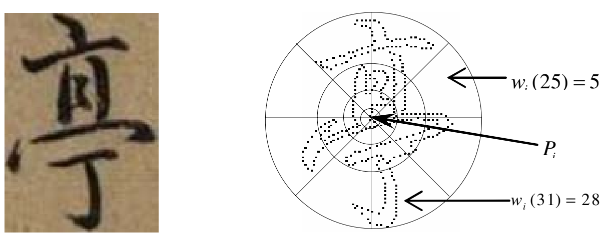
First we briefly introduce the notations that will be used in the rest of paper.

Table 1. Meaning of Symbols Used

Symbols	Meaning
Ω	a set of Chinese calligraphic character
V_i	the i-th character and $V_i \in \Omega$
p_{ij}	the j-th contour point extracted from the i-th character
<x, y>	the coordinate values of point p_{ij}
m	the number of contour points from a character
n	the number of characters in Ω
V_q	a query character user submits
$\Theta(V_q,r)$	a query sphere with centre V_q and radius r
$d(V_i, V_j)$	the distance between two characters

For calligraphic character retrieval, shapes are far more interested than colors and textures. Therefore we propose a shape-similarity-based retrieval method which uses *approximate points context* to describe the shape. Before giving the definition of approximate point context, we show how an original isolated calligraphic character shown in Fig. 2a is represented in the space.

Since character images are represented by pixels (or points). The polar coordinate is more suitable to describe directional relationship of points than the Cartesian one which is shown in Fig. 2b. For direction, we use 8 bins in the same degree to divide the whole space into 8 regions (i.e., directions). As for radius, 4 bins are used with respect to the values of $\log_2 r$ (e.g., in our case the isolated character images are scaled to 32×32, so the chord is divided when r=2, r=4, r=8, r=16 and r=32).



(a) (b)

Fig. 2. Character context. (a) an original isolated calligraphic character example; (b) the correspondence log-polar bins for point context computing when the point is p_i.

Definition 1. *For each point pi of a given point set composed of m sampled points of a calligraphic character Vi, pi's approximate point context is defined as it's relationship with the remainder (m-1) points using coarse k bins:*

$$w_i(k) = \#\{q_j \neq p_i : q_j \in bin(k)\}, k = 0,1,2,......31 \tag{1}$$

where pi means the i-th point which we are computing for the point context, k refers to the k-th bin of point pi.

Note that due to the shape complexity of every character, the number of contour points of each character image, *m*, is also different. Fig. 2b shows an example of how these bins are built and computed for a calligraphic character.

For each point *qi* of the query character *Vq*, point *pj* in a candidate character *Vi* matches the point *qi* if and only if the following constraint is satisfied:

$$dist = |q_i - p_j| = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \le \sigma \times length \tag{2}$$

where (*xi*,*yi*) and (*xj*,*yj*) denote the position of point *qi* and *pj*, *length* is the scale size and σ is an empirical value and is set to 1/4.

Let *MCij*=*MC*(*qi*, *pj*) be the matching cost of two points: *qi* and *pj*, then the matching value of such two points is defined as:

$$MC_{ij} = MC(q_i, p_j) = \frac{1}{2}\sum_{k=1}^{k=32} \frac{[w_i(k) - w_j(k)]^2}{w_i(k) + w_j(k)} \tag{3}$$

where *wi*(*k*), *wj*(*k*) are the values of bin in the histograms at point *qi* and point *pj*, respectively. For each given point *qi* in the query point set, if the point *pj* has the minimum matching cost with point *qi*, then it is regarded as the approximate correspondence point for *qi* since in reality there's no exact corresponding point, except for the case that the candidate image is the same as the query one. Therefore, the minimum point matching cost for *qi* is as follows:

$$PMC_i = \min\{MC(q_i, p_j) : j = 1, 2, ..., m\} \tag{4}$$

Finally, the total matching cost of the two character images (i.e., *Vq* and *Vi*) is defined as:

$$TMC(V_q, V_j) = \sum_{i=1}^{m} \left(PMC_i + \alpha |q_i - corresp(q_i)|^2 \right) \tag{5}$$

where $|q_i - corresp(q_i)|^2$ is the Euclidean distance between point *qi* and its approximate corresponding point *corresp*(*qi*) in a candidate calligraphic character *Vj* and *α* is a weight factor which is set to 0.1 empirically.

4 The CD-Tree Index

When the database size becomes large, it will be inefficient to retrieve similar characters by linear scan. In order to improve the retrieval efficiency, in this section, we develop a novel high-dimensional indexing technique, called the *Composite Distance Tree*(CD-Tree for short), to accelerate the retrieval process.

4.1 Preliminaries

Definition 2. *Given a character V_i, its Start-Distance(SD for short) is the distance between character V_i and character V_O, formally defined as:*

$$SD(V_i) = d(V_i, V_O) \tag{6}$$

where $d(V_i,V_O)$ is the distance between V_i and V_O. Namely, $d(V_i,V_O)=TMC(V_i,V_O)$. *The dimensionality of V_i is the same to that of V_O and the two-dimensional coordinate values of each point in V_O is <0,0> respectively, $i \in [1,n]$.*

As described before, the number of contour points of each Chinese calligraphic character is different, so it is insensible to use the start distance metric to compare with each pair of characters with different dimensionalities. Our solution is to employ the uniform scaling of dimension to normalize the dimensions of characters into a uniform dimension.

Definition 3. *Given a characters V_i, its Uniform Start-Distance(USD for short) is formally defined as:*

$$USD(V_i) = \frac{SD(V_i)}{d_i} \times D \tag{7}$$

where d_i is the dimensionality of V_i, D refers to the uniform dimensionality and $d_i \geq D$.

The design of *CD-Tree* is motivated by the following observations. First, the (*dis*) similarity between characters can be derived and ordered based on their distances to a reference character. Second, distance is essentially a single dimensional value which enables us reuse of existing single dimensional indexes such as B+-tree. Third, the conventional distance-based high- dimensional indexing methods such as NB-tree [15] and iDistance [16] only use a single distance metric to prune the search space in the filtering stage, whose pruning capability is not satisfactory and their performances are not well scaled for very large datasets due to the CPU-intensive distance computation cost of a pare-wise of Chinese characters, which is testified to be much larger than that of the I/O cost [10].

In CD-Tree, all characters in Ω are first grouped into some clusters by an AP-Cluster algorithm [17]. Then the uniform start distance and the centroid distance of each character are computed. Finally, the index key of a character is obtained, which is inserted by an improved B+-Tree. Therefore, in the Section 5.2, a *two-metric*-based CD-Tree indexing method is proposed to further prune the search region such that the distance computation cost of Chinese calligraphic character will be significantly reduced.

Assuming that *n* characters are grouped into *T* clusters (denoted as Cj), then the centroid (Oj) of each cluster(Cj) can be adaptively selected by the AP cluster algorithm [17], where $j \in [1,T]$. So we can model a cluster as a tightly bounded sphere described by its *centroid* and *radius*, which is saved in a class information file.

Definition 4 (Cluster Radius). *Given a cluster Cj, the distance between Oj and the character which has the longest distance to Oj is defined as the cluster radius of Cj, denoted as CRj.*

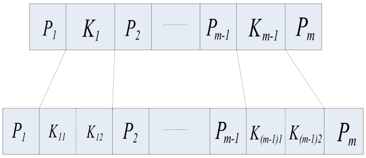


Fig. 3. One-value-based entry *vs*. Two-value-based entry

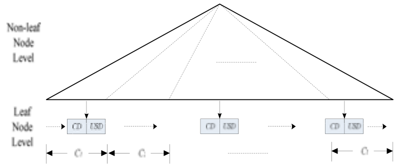


Fig. 4. CD-Tree index structure

Given a cluster Cj, the cluster sphere of it is denoted as $\Theta(Oj,CRj)$, where Oj is the centroid of cluster Cj, CRj is the cluster radius.

Definition 5 (Centroid Distance). *Given a character V_i, its centroid distance is defined as the distance between V_i and Oj, the centre of cluster that V_i belongs to:*

$$CD(V_i)=d(V_i,Oj) \tag{8}$$

where $d(V_i,Oj)=TMC(V_i,Oj)$,$j\in[1,T]$, $i\in[1,\delta]$ and δ is the number of characters in Cj.

4.2 The Data Structure

In order to effectively prune the search region, we propose the *CD-Tree*, high- dimensional indexing scheme based on the NB-Tree [15] and iDistance [16]. As mentioned before, all characters are first grouped into T clusters using an AP-Cluster algorithm [17], then the *uniform-start-* and *centroid-distances* of each character are computed, thus V_i can be represented as a four-tuple:

$$V_i ::= <i, CID, USD, CD> \tag{9}$$

where i refers to the i-th character in Ω; CID is the ID number of the cluster V_i belongs to; USD is the uniform start distance of V_i; CD is the centroid distance of V_i;

For each character V_i in a cluster sphere, its index key can be defined as:

$$Key(V_i) = CID + CD(V_i)/MCD \tag{10}$$

Note that since $CD(V_i)$ may be larger than one, the value of $CD(V_i)$ should be normalized into the range of [0,1] by being divided a large constant MCD. Thus, it is guaranteed that the search range of centroid distance of each character can not be overlapped.

4.3 Building CD-Tree

In Section 5.2, the index key of each character (viz., Eq. (10)) is composed of the *CD* information which can act as a *single metric* to prune the search region. However, as empirically studied in Section 6.2, the efficiency of the *single-metric*-based (i.e., the *CD*-based) approach is not satisfactory. This is because 1). the pruning capacity using a *single-metric* (i.e., *CD*) is much poor than that of *dual-metric*-based (i.e., the *CD*- and *USD*-based) approach; and 2). the distance computation cost of a pair-wise of characters is very high. So the effectiveness of the filtering result will significantly affect the distance computation cost.

To further reduce the distance computation cost in the query processing, we adopt the two metrics to filter the irrelevant characters. However, the combination of the two metrics is not a trivial problem. Our solution is to embed the *USD* value of each character into an index structure which is called improved B$^+$-tree. Different from standard B$^+$-tree[1], for the improved B$^+$-tree, the number of elements in each entry of a node is two. Figure 4 shows the differences between the two node formats of the two kinds of B$^+$-tree (viz., a standard B$^+$-tree and an improved B$^+$-tree). That is, the above part in this figure refers to the node format for a standard B$^+$-tree and the below part represents the node format of the improved B$^+$-tree.

Therefore, for a character, its two values of *CD* and *USD* are recorded in the corresponding entry of CD-Tree whose basic structure is the improved B$^+$-tree, which is shown in Fig. 4. Fig. 5 shows the detail steps of constructing a CD-Tree. Note that the routine ***TransValue***(V_i) is a distance transformation function which is shown in Eq. (10) and ***BInsert***(key,*USD*,*bt*) is a improved B$^+$-tree insert procedure which can both insert a key and the value of *USD* as well.

Algorithm 1. CD-Tree Index Construction
Input: Ω: the character set;
Output: *bt:* the index for CD-Tree;
The characters in Ω are grouped into *T* clusters using the AP cluster algorithm
bt←***newFile***(); /* *create index header file* */
for each character $V_i \in \Omega$ **do**
  The *USD* and *CD* of V_i are computed;
  key(V_i)=***TransValue***(V_i); /* *Function* ***TransValue()*** *is shown in Eq. (10)* */
  BInsert(*key*(V_i),*USD*, *bt*); /* *insert it to* B^+*-tree* */
return *bt*

Fig. 5. The index construction algorithm for CD-Tree

4.4 *k*-NN Search Algorithm

For *n* high-dimensional characters, a *k*-Nearest-Neighbor search is a most frequently used search operation which retrieves the *k* most similar characters that are closest in distance to a given character. In this section, we will focus on *k*-NN searches of Chinese calligraphic character. Fig. 6 shows the two-step filtering processing in *k*-NN search in which a shaded circle represents a query sphere $\Theta(Vq,r)$ with *Vq* as the centre and *r* as the radius. Fig. 7 details the whole search process which is composed of two filtering stages (i.e., *CD-based filtering* (ref. Fig. 6(a)) and *USD-based filtering* (ref. Fig. 6(b))) and one refinement (*i.e., distance computation*) stage. First, when a user submits a query character *Vq*, the search starts with a small radius, and step by step, the radius is increased to form a bigger query sphere iteratively (line3), once the number of candidate characters is larger than *k* (line5), the search stops, then the

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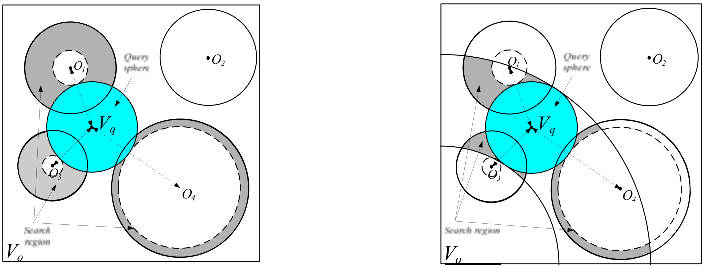
[1] In standard B$^+$-Tree, the number of elements in each entry at leaf node level is one. In our improved B$^+$-Tree, however, the number of elements in each entry at leaf node level is two (i.e., the values of *CD* and *USD* of each character).



(a). First filtering(*CD-based*) (b). Second filtering(*USD-based*)

Fig. 6. The two-step filtering processing in *k*-NN search

Algorithm 2. *k*NN Search
Input: query character V_q, k, Δr
Output: query results S
1. $r \leftarrow 0$, $S \leftarrow \Phi$; // *initialization*
2. **while** ($|S|<k$) // *|S| refers to the number of candidate characters in S*
3. $r \leftarrow r+\Delta r$;
4. $S \leftarrow$ ***RSearch***(V_q,r);
5. **if** ($|S|>k$) **then**
6. **for** i:=1 to $|S|$-k **do**
7. $V_{far} \leftarrow$ ***Farthest***(S, V_q);
8. $S \leftarrow S\text{-}V_{far}$;

RSearch(V_q,r)
9. $S1 \leftarrow \Phi$, $S2 \leftarrow \Phi$;
10. **for** i:=1 to T **do** // *T is the number of clusters*
11. **if** $\Theta(O_i, CR_i)$ **contains** $\Theta(V_q,r)$ **then**
12. $S2 \leftarrow$ ***Search***(V_q,r, i);
13. $S1 \leftarrow S1 \cup S2$;
14. **end loop**
15. **else if** $\Theta(O_i, CR_i)$ **intersects** $\Theta(V_q,r)$ **then**
16. $S2 \leftarrow$ ***Search***(V_q,r, i);
17. $S1 \leftarrow S1 \cup S2$;
18. **return** $S1$; // *return candidate characters*

Search(V_q,r, i)
19. $left \leftarrow i+(d(V_q,O_j)-r)/MCD$;
20. $right \leftarrow i+CR_j/MCD$;
21. $S3 \leftarrow$ ***BRSearch***$[left, right, i]$; // *the first filtering step*
22. **for** each character $V_i \in S3$ **do** // *the second filtering step*
23. **if** $USD(V_q)-r < key(V_i).USD < USD(V_q)+r$ **then** $S3 \leftarrow S3\text{-}V_i$; // *$V_i$ is removed from S3*
24. **if** $d(V_q,V_i)>r$ **then** $S3 \leftarrow S3\text{-}V_i$; // *the refinement stage*
25. **return** $S3$; // *return the candidate character set*

Fig. 7. *k*-NN search algorithm

($|S|$- k) characters which are longest to the query one are identified (lines 6-7) and removed from S (line8). It is worth mentioning that the symbol $|S|$ has two meanings: 1). it is the total number of candidate characters in S; 2). the candidate characters in S are the characters whose distance to the query character Vq are less than or equal to the query radius r. In this way, the k nearest neighbor characters of Vq is just returned. Before examining the algorithm, we briefly introduce some of important routines. Routine ***RSearch***(Vq,r) is the main range search function which returns the candidate characters of range search with centre *Vq* and radius *r* and ***Search***(*Vq,r*) is the implementation of the range search. ***Farthest***(*S,Vq*) returns the character which is the longest from *Vq* in *S* and *S i*s denoted as the candidate character set. ***BRSearch***(*left*, *right*) is a improved B+-tree range search function.

5 Experimental Results

In this section, we present an extensive performance study to evaluate the effectiveness and efficiency of our proposed retrieval and indexing method. The Chinese Calligraphic characters image data we used are from *China-America Academic Digital Library Project* [18] which contains a set of contour point features extracted from the 12,000 character images in which each feature point is composed of a pair of coordinates <*x axis*, *y axis*>.

We implemented the shape-similarity-based retrieval approach and the CD-Tree index in *C* language in which a B+-tree is as the single dimensional index structure. The index page size of B+-tree is set to 4096 Bytes. All the experiments are run on a Pentium IV CPU at 2.0GHz with 256 Mbytes memory. In our evaluation, we use the number of page accesses and the total response time as the performance metric. All the following experiments' performances are measured in terms of the average disk page access, and the CPU time over 100 queries.

5.1 Effectiveness of the Retrieval Method

In the first experiment, we have implemented an online retrieval system for Chinese calligraphic characters to testify the effectiveness of our proposed retrieval method comparing with the Projecting method [2] and EMD method [9]. As shown in Fig. 8, when user submits a example Chinese calligraphic character by drawing a character "天", the candidate characters are retrieved by the system with the aid of CD-Tree index. The right part of the figure is the query input interface and the left part is to illustrate the query results.

Denote the set of ground-truth as *rel*, and the set of results returned by a *k*-NN search as *ret*, the recall and precision achieved by this retrieval method is defined as:

$$recall = \frac{|rel \cap ret|}{|ret|}, \quad precision = \frac{|rel \cap ret|}{|rel|} \tag{11}$$

Fig. 9 illustrates a *Recall-Precision* curve for the performance comparisons of the *shape- similarity*(SS) method, the projecting method [2] and the EMD method [9]. It compares the average retrieval result (the average precision rate under the average recall rate) of 20 characters queries randomly chosen from the database. Each of them has more than 4 different calligraphic styles. The figure shows that the retrieval performance of the *SS* method is better than those of the other two methods mentioned above by a large margin.

Fig. 8. One retrieval example

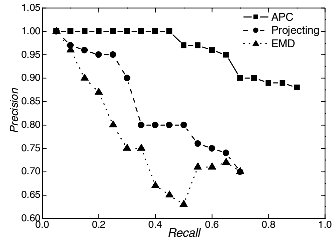
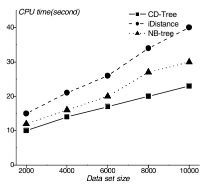
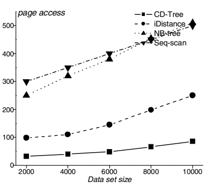


Fig. 9. recall *vs*. precision

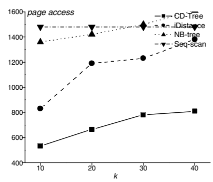


(a) CPU cost *vs.* Data size

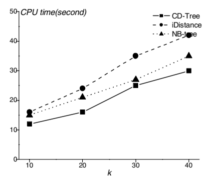


(b) I/O cost *vs.* Data size

Fig. 10. Effect of data size



(a) *K vs.* Page Access



(b) *K vs.* CPU Cost

Fig. 11. Effect of *k*

5.2 Efficiency of CD-Tree Index

In the following, we test the performance of our proposed indexing method—CD-Tree under different sizes of databases and different selectivity.

5.2.1 Effect of Data Size

In this experiment, we measured the performance behavior with varying number of characters. Figs. 10a shows the performance of query processing in terms of CPU cost. It is evident that CD-Tree outperforms sequential scan significantly. The CPU cost of CD-Tree increases slowly as the data size grows. It's worth mentioning that the CPU cost of sequential scan is ignored since the computation cost of it is very expensive. In Figs. 10b, the experimental result reveals that the I/O cost of CD-Tree is superior to other three methods. NB-tree exhibits a dramatically increase in terms of page access and it finally exceeds the sequential scan when the data size is 8000 because of its I/O intensive operations during query process.

5.2.2 Performance Behavior with k(Selectivity)

In this section, we proceed to evaluate the effect of *k*(selectivity) on the performance of a *k*-NN search by using CD-Tree. Figs. 12a and 12b both indicate that when *k* ranges from 10 to 40, CD-Tree is superior to other methods in terms of page access and the CPU cost. The results conform to our expectation that the search region of CD-Tree is significantly reduced and the comparison between any two characters is a

CPU-intensive task. The CPU cost of sequential scan is ignored due to the expensive computation cost of it.

6 Conclusions

In this paper, we introduced a novel web-based retrieval framework of historical Chinese calligraphic character images, in which two main components are included, such as 1). an efficient approach to retrieving Chinese calligraphic characters by matching character images based on approximate point correspondence algorithm; 2). a novel composite-distance-tree (C*D-Tree*)-based high-dimensional indexing scheme is then proposed to boost the retrieval performance of the large Chinese calligraphic characters. The prototype retrieval system is implemented to demonstrate the applicability and effectiveness of our new approach to Chinese calligraphic character retrieval.

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