Sylvana Kroop
Alexander Mikroyannidis
Martin Wolpers *Editors*

Responsive Open Learning Environments

Outcomes of Research from the ROLE Project

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Personal Learning Environments (PLEs): Visions and Concepts

Alexander Mikroyannidis, Sylvana Kroop, and Martin Wolpers

Abstract Personal learning environments (PLEs) hold the potential to address the needs of formal and informal learners for multi-sourced content and easily customisable learning environments. This chapter presents an overview of the European project ROLE (Responsive Open Learning Environments), which specialises in the development and evaluation of learning environments that can be personalised by individual learners according to their particular needs, thus enabling them to become self-regulated learners.

Keywords Personal learning environment • Self-regulated learning • Responsive open learning environment

Introduction

An ageing society and a flexible economy need lifelong learning more than ever, otherwise risking that school kids today know more than employees trained half a decade ago. Lifelong learning requires learners to actively control their learning activities while addressing the requirements imposed on them in their respective life contexts. Life context here can be the school, the university, the workplace, the hobby, etc. This leads to a shift from a centralised institutional teaching approach to a more learner-centred decentralised learning approach (Wilson 2005). In order to support this shift, learning environments must change to be more responsive and open, allowing effectively addressing individual needs of learners and teachers.

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In this chapter, we will reflect on the approach of the European project ROLE (Responsive Open Learning Environments[1]). ROLE enables learners individually to compile their personal learning environments (PLEs) according to their particular needs and goals. Consequently, the ROLE approach supports self-regulated learning (SRL) while taking into account the requirements from the roles of the learners and the teachers.

The remainder of this chapter is structured as follows: Recent advances in personalised and SRL are introduced. Subsequently, the widget-based approach of the PLE is presented, along with the process of building a PLE using widgets. This is followed by an introduction to the ROLE project and its key innovations, with particular emphasis on evaluating these innovations via a number of case studies and test beds. An example of a recent research initiative that builds upon the results of the ROLE project is provided in the section that presents the weSPOT project. Finally, the chapter is concluded with a summary of the key ROLE contributions to technology-enhanced learning and an overview of what is presented by each chapter in the rest of this book.

Personalised and Self-Regulated Learning

The Learning Management System (LMS) has dominated technology-enhanced learning for several years. It has been widely used by academic institutions for delivering their distance learning programmes, as well as for supporting their students outside the classroom. The LMS has been a powerful tool in the hands of educators, enabling them to complement face-to-face teaching in the classroom with remote work by individual students, as well as groups of them (Bri et al. 2009; Wainwright et al. 2007; Abel 2006; Watson et al. 2007).

However, the advent of Web 2.0 has altered the landscape in technology-enhanced learning. Learners nowadays have access to a variety of learning tools and services on the cloud. These tools and services are usually provided by different vendors and in many cases are open and free. However, augmenting and configuring these diverse and distributed tools and services in order to address the needs and preferences of individual learners is a significant challenge for modern online learning environments.

This ongoing transition from the traditional approach of the LMS towards Web 2.0-based learning solutions bears significant benefits for learners. It puts emphasis on their needs and preferences, providing them with a wider choice of learning resources to choose from. Learners usually switch learning contexts continuously, adapting to the respective needs automatically. The LMS is not able to provide learners with the required flexibility. Furthermore, the LMS is a closed system that does not allow the learner to take her achievements with her when changing the

[1] http://www.role-project.eu

LMS-providing learning organisation, e.g. while starting a new job, the previously used LMS-profile cannot easily be transferred to the new one used at the workplace.

The PLE is a facility for an individual to access, aggregate, manipulate, and share digital artefacts of their ongoing learning experiences. The PLE follows a learner-centric approach, allowing the use of lightweight services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides learners with a variety of services and hands over control to them to select and use these services the way they deem fit (Chatti et al. 2007; Wilson 2008).

The emergence of the PLE has greatly facilitated the use and sharing of open and reusable learning resources online. Learners can access, download, remix, and republish a wide variety of learning materials through open services provided on the cloud. Open Educational Resources (OER) can be described as "teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others depending on which Creative Commons license is used" (Atkins et al. 2007).

SRL comprises an essential aspect of the PLE, as it enables learners to become "metacognitively, motivationally, and behaviourally active participants in their own learning process" (Zimmerman 1989). Although the psycho-pedagogical theories around SRL predate very much the advent of the PLE, SRL is a core characteristic of the latter. SRL is enabled within the PLE through the learner-driven assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm, the PLE allows learners to regulate their own learning, thus greatly enhancing their learning outcomes (Steffens 2006; Fruhmann et al. 2010).

The Widget-Based Approach of the PLE

As online learners become more discerning in terms of the choices related to the types and styles of their potential study materials, they will potentially seek content from multiple sources. In addition, because of the flexibility and ease of use that enables many users to customise that content, those same learners may wish to personalise their learning environment.

The PLEs presented in this book are primarily enabled by widgets, which are micro-applications performing a dedicated task. This task can be as simple as showing news headlines or weather forecasts, but also more complex like facilitating language learning or collaborative authoring. Widgets can be either desktop based or web based. Desktop-based widgets reside locally on your computer and may access the web for information, such as a desktop widget that shows the local temperature and weather. Web-based widgets reside on the web and can be embedded on a web page, such as an RSS reader widget that fetches news on your start

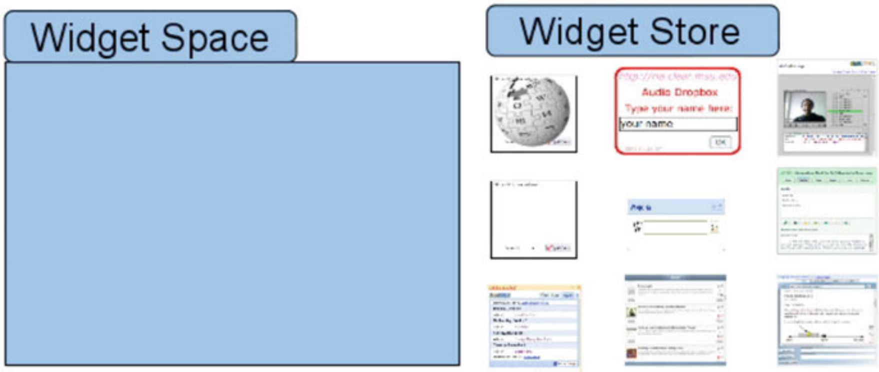

Fig. 1 Browser- and widget-based PLE concept

page. Web-based widgets have proven quite popular as they enhance the interactivity and personalisation of web sites.

As already mentioned above, the theoretical idea of PLEs is not a specific software application. A PLE is instead a concept based on the idea to have learner-centric Web 2.0-based environments individually designed. It is not a one-size-fits-all learning environment but a personalised environment a learner takes control over his/her own learning process instead of being controlled by a pre-delivered orchestration of learning goals, tools, services, and content. In PLE research it is deemed essential to have a learner challenged by offering her the ability to create her individually controlled and preferred learning environment.

In the ROLE project, the basic equipment for creating PLEs has been developed according to the idea of an easy drag-and-drop system of widgets.

On the one hand, a repository (widget store) is necessary to store and administrate useful widgets. On the other hand an enabler space (widget space) is necessary to have learners their individually preferred widgets integrated, used, and managed in their personal style. Figure 1 outlines this approach schematically.

From a user perspective, ROLE is Software as a Service (SaaS) (Mell and Grance 2011; Vaquero et al. 2008)—the user does not install and run it locally. This paradigm affects three main aspects of the user-visible parts of ROLE:

- *Widget space*: The widget space contains a number of personally selected learning widgets whereby all of them access and use already existing and established external OER. It is the virtual environment where the user installs and uses its widgets.
- *Single widget*: A single widget abstracts (accesses and uses) at least one single external resource. There are widgets accessing and using just one single external resource, e.g. a Wikipedia widget or an LEO dictionary widget. Furthermore, some widgets have been implemented to make use of cloud computing to an extensive degree. One example is the “ROLE translator widget” which accesses and displays the results of different popular resources such as LEO.org, dict.cc,

Wikipedia, and Google translator. The results of translating a specific term are used from all translating resources at the same time and are displayed in the same place by using the ROLE translator widget. Thus a learner has a better and more critical overview by being able to quickly compare the provided Web 2.0-based translation data. One more interesting example of a cloud computing-based widget is "Binocs" which displays search results by using different external resources and depending on the used resources of a personal network of trusted friends, colleagues, and experts (Govaerts et al. 2011). All widgets can be found in the ROLE Widget Store described in the following section.

- *Multiple devices*: ROLE widgets and content can be accessed and used with different devices. Depending on the widgets and content, it can be used by all kind of browser-based applications on notebooks, smartphones, tablets, etc.

Building a Widget-Based PLE

In order to build a widget-based PLE, the learner will need to access a widget store. A widget store is a directory of widgets, where widgets are commonly categorised according to their purpose, e.g. widgets for planning, communication, and collaboration. An example of such a categorisation is shown in Fig. 2. The learner can browse and download the widgets, as well as provide feedback on them in the form of ratings and comments. The ROLE project has built a widget store dedicated to widgets for learning purposes.[2]

After selecting the appropriate widgets, the learner needs to add them to the web space of their choice and start using them for their learning, either by themselves or in collaboration with other learners. Widgets can also be embedded inside an LMS, such as Moodle, thus enhancing its functionality and content, as shown in Fig. 3. Additionally, ROLE offers a facility for creating a shared learning space and populating it with widgets.[3]

For more information on building a PLE and using it to become a self-regulated learner, one can refer to the following free online courses that have been developed by ROLE:

- *Responsive open learning environments*[4]: This course provides an overview of the concepts behind PLEs and also demonstrates a selection of ROLE widgets within learning activities. Figure 4 shows such an activity, where the learner is invited to use a ROLE widget in order to complete a series of learning tasks.

[2] http://www.role-widgetstore.eu

[3] http://role-sandbox.eu

[4] http://labspace.open.ac.uk/course/view.php?id=7433

Fig. 2 The ROLE widget store offers widgets (tools) for a variety of learning purposes, categorised according to learning tasks

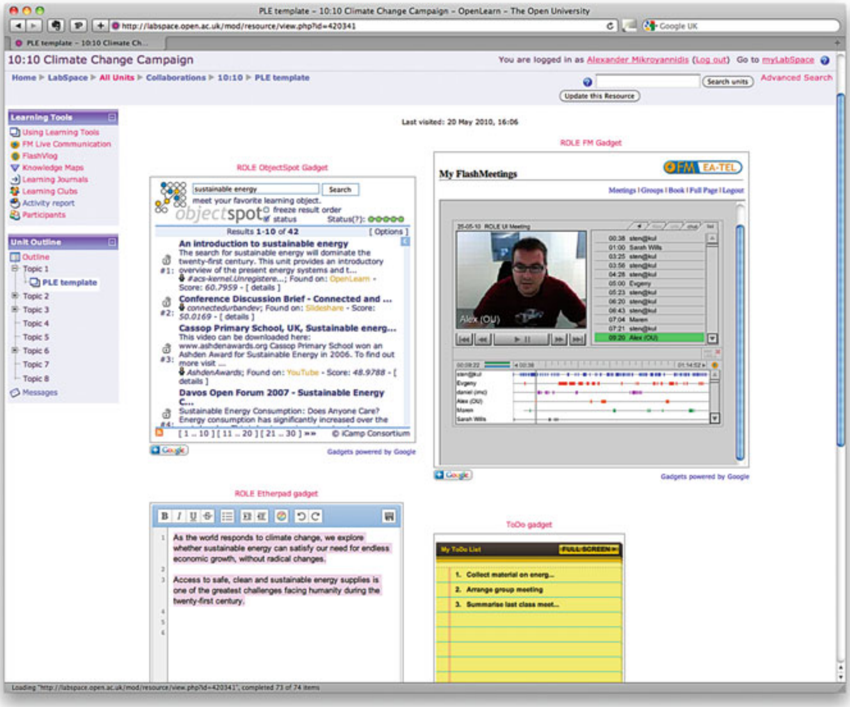

Fig. 3 ROLE widgets embedded inside a Moodle course. The learner uses them to search for learning resources, as well as collaborate with other learners through videoconferencing and a shared writing pad

- *Self Regulated Learning*[5]: This course introduces the concept of SRL and guides learners into using the ROLE tools in order to apply the SRL principles into their own learning.

The content of these two courses is also available as a free interactive eBook, developed for the iPad and MacOS (Mikroyannidis et al. 2013a). The eBook provides an introduction to the new learning technologies that empower SRL and PLEs. A selection of widgets that will help readers build their own PLE and become a self-regulated learner are also demonstrated. Readers have an opportunity to interact with these widgets through a set of learning activities included in the eBook.

[5] http://labspace.open.ac.uk/course/view.php?id=7898

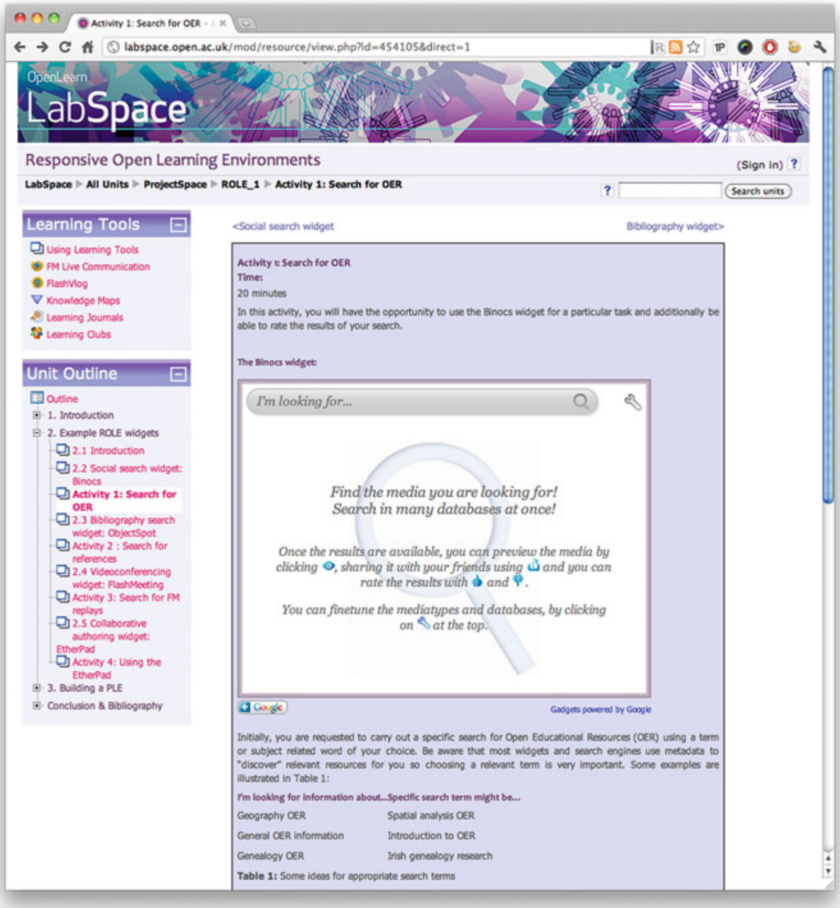

Fig. 4 A learning activity of a free online course developed by ROLE, featuring a search widget and a step-by-step guide on completing a series of learning tasks

The ROLE Project and Its Key Innovations

ROLE is a European-funded initiative with 16 internationally renowned research groups from six European countries and China. It started on February 2009 with a duration of 4 years. ROLE was established to research and explore a variety of tools and services that enable learners to build their PLE, based on their needs and preferences. ROLE has brought forward the innovations in PLEs and SRL, through research in the following directions:

- User-centric approach to learning environments with a focus on end-user development to design and control a PLE.

- Contemporary pedagogical models for personalisation in learning networks, SRL and collaboration in networked communities.
- Contemporary engineering frameworks for designing, integrating, orchestrating, and evaluating learning services, tools, and content.
- Frameworks for evaluating learner interactions in learning networks.

The notion of lifelong learning as discussed today formulates a number of requirements on the technological basis as well as the associated learning and business/organisational processes. As our target group ranges from all possible domains and roles, e.g. learners, teachers, companies, employer, employees, and learning organisations, opportunities arise that will support the current shift in education towards more self-regulated learners (Van Harleman 2006) in scenarios, where the teacher role shifts more towards a mentoring role: the centralised institutional teaching approach shifts to a more learner-centred decentralised learning approach (Wilson 2005).

The ROLE project provides solutions to this set of complex challenges by advancing the state of the art in the technology and methodology. The following sections outline the ROLE approach in technology and methodology.

Technology: interoperable infrastructure enables PLE composition—ROLE has provided an infrastructure that enables learners to create their own PLEs, while maintaining a close link to the rules and restrictions of the education-providing organisation (Isaksson 2013; Dahrendorf 2013). In essence, the idea is to loosen the control on the learner while maintaining the ability to certify learner achievements. For example, the learner chooses the required learning tools and contents from a wide selection and compiles them into her individual PLE. At the same time, the education provider can control which tools and contents can be chosen by the learner.

ROLE tools and content within the PLE are able to communicate with each other in order to enable tools and contents to react to each other based on the user interaction. Finally, rather than replacing LMS, the ROLE approach allows the successful augmentation of existing learning environments. This way, the costs for introducing the ROLE approach to existing learning environments is significantly reduced, which fosters its uptake.

Methodology: self-regulation as the key learning paradigm—Learners today are not aware of the advanced learning paradigm of SRL. In most cases, the basic components of SRL, that is, cognition, meta-cognition, motivation, affects, and volition (Efklides 2009), are used by learners intuitively without understanding the conceptual background. Apart from supporting SRL in PLE creation and use through respective recommenders, collaboration tools and best practice sharing, ROLE raises awareness through a number of dedicated learning resources. These range from short videos explaining the SRL principles (see for example http://youtu.be/jTa1vOH6JjA), to bespoke online courses about SRL that help teachers and students understand the mechanics and benefits behind SRL, such as the ones introduced in the previous section of this chapter.

The ROLE Case Studies and Test Beds

The ROLE innovations in technology and methodology have been proven successful in a number of case studies that investigate the impact of PLEs on different forms of learning. Each case study has employed large test beds that have run continuously throughout the lifetime of the project and beyond (Mikroyannidis and Connolly 2012, 2013). The ROLE test beds cover a wide variety of rich contexts inside and outside of Europe, in which there is potential for significant impacts on both personalised and SRL. Each test bed concentrates on researching a large sample of representative individuals; this has enabled ROLE as a whole to collect experiences covering a large variety of learning contexts and requirements. The ROLE case studies and test beds are presented in detail in subsequent chapters of this book. A brief overview is provided below:

Case Study 1: Using Widget Bundles for Formal Learning in Higher Education—This case study explores the usefulness of the PLE for facilitating and complementing the learning that happens inside the classroom in Higher Education. The test beds of this case study are three universities: the RWTH Aachen University (RWTH) in Germany, the Shanghai Jiao Tong University (SJTU) in China and the University of Uppsala in Sweden. These test beds present a variety of learning cultures, different profiles of students, as well as different methods of teaching and learning, e.g. synchronous versus distant learning. Bespoke widget bundles were developed by the ROLE project in order to address the learning contexts and requirements of these test beds. These widget bundles were employed in different learning domains to support different types of learning in these test beds and were evaluated by both the teachers and the students.

Case Study 2: Designing PLE for Higher Education—In this case study, the potential benefits associated with enabling teachers and students to design, build, and use their PLEs collaboratively are investigated. The test beds of this case study are the Tongji University in China and three Swiss universities, namely the University of Fribourg, the University of Geneva, and the EPFL. In these test beds, a Web 2.0 platform enabling the construction, the sharing, and the repurposing of PLEs has been introduced. Participatory design and validation activities have been carried out in the framework of Higher Education, aiming at understanding the benefits of PLEs in academic institutions.

Case Study 3: Exploring OER for Informal Learning—This case study concerns the learner's potential transition from formal to informal learning. The test bed of this case study is OpenLearn,[6] an OER repository offered by the Open University in the UK. OpenLearn users are primarily informal learners, who want to find and study OER either individually or in collaboration with others. The ROLE intervention in the OpenLearn test bed has been about improving the informal learning experience in a number of ways. First of all, by enabling individuals to build and personalise their learning environment, thus gaining more control over the use and

[6] http://www.open.edu/openlearn

manipulation of study materials. Additionally, the adoption of certain ROLE tools inside OpenLearn is offering further value to learners through fostering learning communities. This presents an opportunity to individual informal learners to be part of a shared learning experience instead of a lone study.

Case Study 4: Technology Enhanced Workplace Learning: Learning in the workplace is targeted by this case study, which explores the challenges and opportunities associated with SRL in the workplace and the sharing of best practices among employees. The test bed in question is Festo Lernzentrum Saar GmbH in Germany. Festo has experimented with the notion of the Personal Learning Management System (PLMS), a crossover between the PLE and the LMS. The PLMS aggregates learning resources and applications available in the web and selected by the learner. It facilitates learners in planning their learning activities, searching for learning content and tools, training and testing, as well as in reflecting and evaluating their learning progress.

The evaluation results from the ROLE test beds are presented in detail in the chapters of this book that discuss each case study. Overall, the evaluation results indicate the best suitability of the ROLE approach for self-regulated learners while providing significant improvements even in traditional learning scenarios where ROLE tools are used for homework-like assignments. Additionally, the successful evaluation of the ROLE approach has led partners to include it in their commercial products and consulting practices.

PLEs for Inquiry-Based Learning: The weSPOT Project

The ROLE project has been a pioneering initiative in PLE research. It has paved the way for more national and international research initiatives that explore the potential applications and benefits of PLEs in different learning contexts. Both the theoretical and technological frameworks developed by ROLE have been taken upon and extended by recent research projects. A prominent example of such an initiative is the weSPOT project, which is investigating the potential impact of PLEs in Inquiry-Based Learning.

Inquiry-based learning (IBL) enables learners to take the role of an explorer and a scientist as they try to solve issues they came across and that made them wonder, thus tapping into their personal feelings of curiosity. IBL leads to structured knowledge about a domain and to more skills and competences about how to carry out efficient and communicable research.

The European project weSPOT[7] adopts a PLE-based approach in order to support learners and educators in IBL (Mikroyannidis et al. 2013c). The project focuses on IBL with a theoretically sound and technology-supported personal inquiry approach. weSPOT supports the meaningful contextualisation of scientific

[7] http://wespot.net

concepts by relating them to personal curiosity, experiences, and reasoning. weSPOT addresses several challenges in the area of science education and technology support for building personal conceptual knowledge (Mikroyannidis et al. 2013b).

These principles have driven the development of the weSPOT inquiry space,[8] a personal and social IBL environment that reuses and extends the Elgg open-source social networking framework.[9] The weSPOT inquiry space has been built based on the following requirements (Mikroyannidis 2014):

- A widget-based architecture enables the personalisation of the inquiry environment, allowing teachers and students to build their inquiries out of mashups of inquiry components.
- Students can connect with their peers and form groups in order to build, share, and perform inquiries collaboratively.

Inquiries in the weSPOT inquiry space are consistent with the weSPOT pedagogical IBL model (Protopsaltis 2013). According to this model, an inquiry consists of the following six phases: (1) question/hypothesis, (2) operationalisation, (3) data collection, (4) data analysis, (5) interpretation/discussion, and (6) communication.

The weSPOT inquiry space enables its users (teachers and students) to create mashups of their preferred inquiry components, assign them to different phases of an inquiry, share them with other users, and use them collaboratively in order to carry out an inquiry. When creating a new inquiry, users are provided with a set of recommended inquiry components for each phase of the inquiry. They can then customise these sets of components by adding, removing, and arranging inquiry components for each phase of the inquiry.

The weSPOT inquiry space offers a variety of inquiry components to teachers and students, enabling them to create, edit, and share hypotheses, questions, answers, notes, reflections, mind maps, etc. Some of these components communicate with the APIs of REST web services offered by external tools. One of these external tools is the ARLearn mobile app,[10] which allows students to collect different types of data (photos, videos, measurements, etc.) with their smartphones and share them with other inquiry members via the weSPOT inquiry space. A Learning Analytics dashboard visualises all the activities taking place within an inquiry, enabling teachers to monitor the progress of their students and students to self-monitor their progress.

Figure 5 shows an example mashup of inquiry components for a particular phase of an inquiry that explores the everyday uses of batteries. The phase is labelled "Discuss the findings" and corresponds to the "Interpretation/Discussion" phase of the weSPOT IBL model. In this phase, the members of the inquiry use collaboratively three inquiry components in order to discuss and interpret their findings.

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[8] http://inquiry.wespot.net

[9] http://elgg.org

[10] http://portal.ou.nl/en/web/arlearn

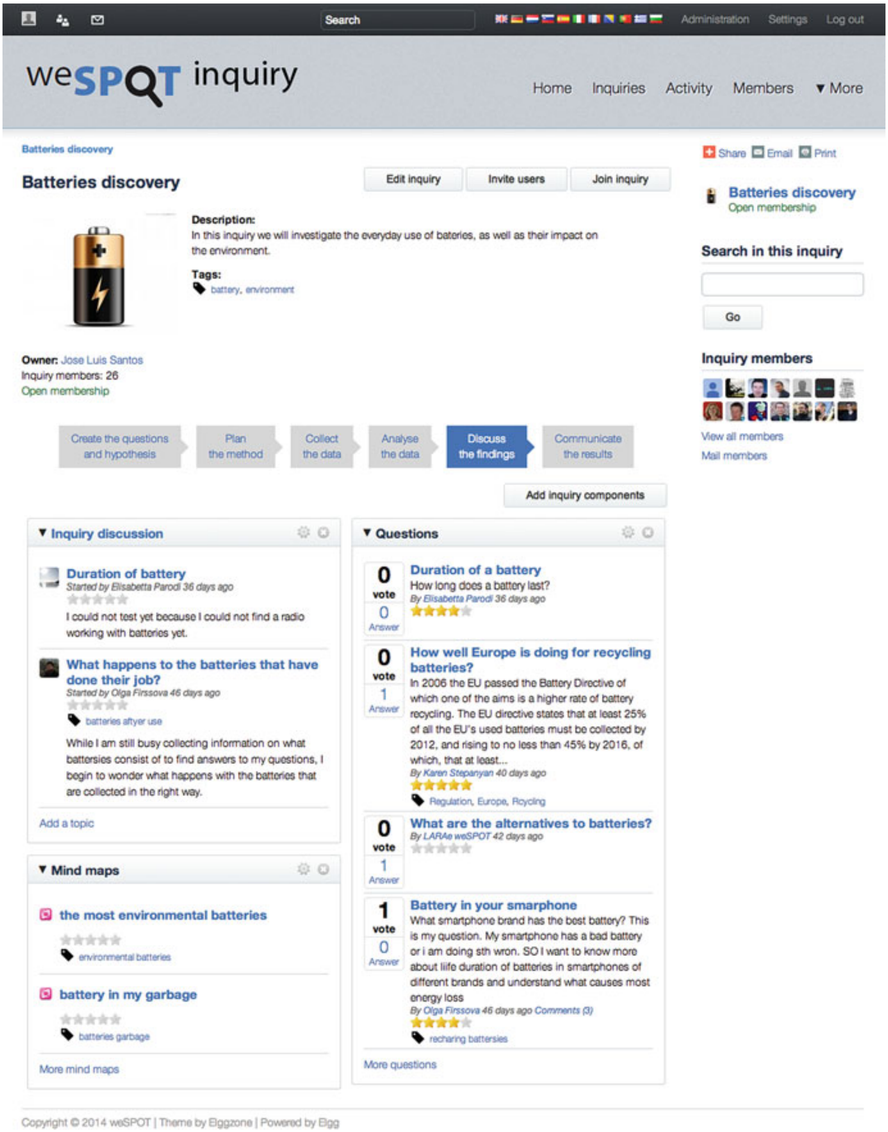

Fig. 5 A mashup of inquiry components for discussing and interpreting the findings of an inquiry

They use the "Inquiry discussion" component to exchange their views asynchronously in discussion forums. They also use the "Questions" component in order to provide answers to the key research questions of this inquiry and vote for the best answers. Finally, they create and share mind maps containing interpretations of their findings via the "Mind maps" component.

Additionally, users have access to external resources and widgets and can use them in their mashups together with the inquiry components offered by the weSPOT inquiry space. These resources and widgets originate from external LMSs, such as Moodle or Blackboard, or from external repositories of widgets, such as the one offered by the European project Go-Lab.[11] In order to integrate external resources originating from LMSs, we have implemented the IMS Learning Tools Interoperability (LTI) specification,[12] thus allowing teachers to include in their inquiries either course components from LMSs, such as discussion forums or quizzes, or entire LMS courses.

Conclusions and Book Overview

In summary, the vision of the ROLE project has been to provide the necessary infrastructure and processes for any learner across the world to assemble their own PLE, while enabling the education provider to exercise the necessary control to facilitate the certification of the learning achievements. From a technical point of view, the approach taken by ROLE enables the flexible composition of technologies by the end user in the sense of mashing-up learning tools and technologies at the "clients" side.

Today's rapidly changing education and employment conditions demand a lifelong learner who is flexible, motivated, and in control of his or her learning. The ROLE initiative has significantly advanced the state of the art in technology-enhanced learning, by providing lifelong learners with the tools and support they need for personalising their learning and developing a wide range of SRL skills.

The rest of this book presents in detail the theoretical and technological advances of the ROLE project, with particular emphasis on the applications of these advances in the case studies investigated by the project, as well as the evaluation results obtained by the project's test beds. More specifically, Chap. 2 introduces the SRL approach of the project, consisting of a formal framework that describes the SRL process, related competences, and guidelines. Additionally, the methods offered by the ROLE SRL framework on supporting learners in order to learn in a self-regulated way are presented.

Chapter 3 presents the evaluation framework and methodology of the project. The ROLE evaluation framework is case study-based and follows a multi-method approach. It integrates technological, organisational, psycho-pedagogical, and social aspects. At the same time, it provides a flexible and adaptive methodology, capable of accommodating the changes that are inevitable in the emerging field of personalised and SRL.

[11] http://www.golabz.eu/apps

[12] http://www.imsglobal.org/lti/index.html

Chapters 4–7 present the project's case studies and the test beds employed in each case study. As mentioned earlier in this chapter, the ROLE case studies and test beds cover a wide variety of learning contexts, ranging from formal to informal learning and from higher education to distance learning and workplace learning. Each test bed is presented according to its specific learning scenarios and requirements, the stakeholders involved, as well as the PLE intervention achieved by the project and the evaluation results.

Finally, Chap. 8 discusses the lessons learned from the development of the project's PLE framework. In particular, the overall architecture and its components, as well as the platforms in which the ROLE technological framework has been integrated are presented. In addition, the experiences and lessons learned from the design and development of the ROLE technological framework are discussed, together with the lessons learned from the collaboration both internally within the ROLE development team and externally with other open-source projects.

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Supporting Self-Regulated Learning

Alexander Nussbaumer, Ingo Dahn, Sylvana Kroop, Alexander Mikroyannidis, and Dietrich Albert

Abstract Self-regulated learning (SRL) competences are crucial for lifelong learning. Their cultivation requires the right balance between freedom and guidance during the learning processes. Current learning systems and approaches, such as personal learning environments, give overwhelming freedom, but also let weak learners alone. Other systems, such as learning management systems or adaptive systems, tend to institutionalise learners too much, which does not support the development of SRL competences. This chapter presents possibilities and approaches to support SRL by the use of technology. After discussing the theoretical background of SRL and related technologies, a formal framework is presented that describes the SRL process, related competences, and guidelines. Furthermore, a variety of methods is presented, how learners can be supported to learn in a self-regulated way.

Keywords Self-regulated learning • Learning guidance • Learning models • Personal learning environments

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Introduction

The ROLE project[1] has aimed to achieve progress beyond the state of the art in user-centric responsive and open learning environments, which included psycho-pedagogical models beyond instructional design. ROLE was researching and developing a psycho-pedagogical framework for supporting the individual composition and usage of learning environments. The most important goal of this framework is to support learners to learn in a self-regulated way in responsive open learning environments.

The self-regulated way of learning[2] is a fundamental aim for ROLE. The reason for this aim is the orientation towards lifelong learning, which means that learning with ROLE takes place across institutional boundaries. This includes consideration of formal, non-formal, as well as informal learning. These dimensions of learning organisations are seen as fluent, rather than as rigid categories.

In order to manage the challenge of learning on their own in the ROLE context, learners require certain self-regulated learning (SRL) competences. For this reason, ROLE aims at enhancing this kind of competences by providing support strategies on different levels depending on the learner's needs and competences. Basically the support strategy depends on the learning situation. In a blended learning situation a teacher or tutor plays an important role for supporting SRL, in a collaborative situation peers play a role and have influence on the learning trajectory, and finally technology-mediated approaches play a role in all learning situations. All of them can be interconnected and the support strategy depends on the respective situations.

This chapter is widely based on ROLE deliverables, especially Deliverable D6.1 (Nussbaumer et al. 2013) has been taken into account. The remainder of this chapter is structured as follows: Section "Theoretical Background" gives an overview on the theoretical background of SRL. Learning technology and its relation to SRL is described in section "Related Work and Technology". Section "Models and Framework" presents the general framework on SRL and includes several models. A variety of guidance strategies are listed in section "Support Strategies". The experiences made at the ROLE test beds and in several workshops with students and researchers are reported in section "Evaluation Results, Challenges, and Barriers". Finally, the conclusion section summarises the key findings.

Theoretical Background

From a psycho-pedagogical point of view, SRL is a complex field of research that combines motivational as well as cognitive and personality theories. Components of SRL are cognition, meta-cognition, motivation, affects, and volition (Kitsantas 2002).

[1] http://www.role-project.eu/

[2] See self-regulated learning teaser video, http://www.youtube.com/watch?v=jTa1vOH6JjA.

According to Zimmerman (2002), students can be described as self-regulated to the degree that they are meta-cognitively, motivationally, and behaviourally active participants in their own learning process. To define students' learning as self-regulated, they have to use specific strategies for attaining their goals and all this has to be based on self-efficacy perceptions. In this context there are mainly three elements important, namely the SRL strategies of students, their perceptions of self-efficacy regarding their performance skills, and the commitment to their goals. The learners are active and able to control, monitor, and regulate their cognition, motivational state, behaviour, and context. Furthermore, the learners set goals and try to achieve them through progress-monitoring. These self-regulatory activities are mediators between personal characteristics, contextual features, and actual performance in the learning process. In a meta-analysis conducted by Hattie (2009), it turned out that performing self-regulatory activities in the learning process is one of the most effective methods to reach the learning goals.

Zimmerman has developed a *cyclic SRL model* (Zimmerman 2002) consisting of three phases, which are the forethought phase (goal setting or planning), the performance phase (self-observation processes), and the self-reflection phase (self-reflection processes). According to this model, learning performance and behaviour consist of both cognitive and meta-cognitive activities. The cognitive activities are related to dealing with subject domains, for example, acquiring domain knowledge through reading. The meta-cognitive activities are related to thinking about and regulating the cognitive activities, for example, making a plan about domain knowledge acquisition.

A similar approach is pursued by Boekaerts (1999) who developed the *layered SRL model* consisting of three layers. The first layer is about the regulation of the self, which is related to the choice of goals and resources. The second layer focuses on the regulation of the learning process that relates to the use of meta-cognitive skills to direct the learning process. The third layer describes the regulation of the processing modes, which describes the choice of cognitive strategies. Also this model deals with cognitive and meta-cognitive activities, as well as with goals and resources.

A key role in SRL is given to *learning activities* that are also called learning strategies or learning processes. Dabbagh and Kitsantas (2004) listed six key processes that are essential for SRL, namely goal setting, self-monitoring, self-evaluation, task strategies, help-seeking, and time management.

- The *goal setting* process is defined as the outcome of a learning process and identifies strategies how to reach these goals. Goal setting motivates the learner's choice of and attention to the relevant tasks and it also motivates to attain higher effort and higher persistence over the course of time (Zimmerman 2002). Furthermore, goal setting influences learning through affective reactions, for example, higher self-satisfaction when goals are reached. Also the difficulty of a goal is an important factor for performance that increases with the difficulty level of the goal (Locke and Latham 2002).

- *Self-monitoring* is defined as one's reflected attention to an aspect of behaviour that directs the learners' attention to the task and assists them in evaluating the outcomes of their efforts. Self-monitoring is important because it helps learners attaining their goals by defining adequate learning adjustments.
- *Self-evaluation* is the process where the learner compares the learning outcome with their own goals. It fosters better skill acquisition, self-efficacy beliefs, intrinsic interest, and self-satisfaction about performance.
- *Task strategies* is defined as the process of the learner who applies strategies which help reach their own goals. Studies indicate that students who applied strategies for learning had a better performance than students who did not apply them as much (Pintrich 1990).
- *Help-seeking* is taking place if a learner identifies and calls upon outside resources. Thereby not only human help is meant, but also external analogue and digital resources.
- *Time management* is the process where learners manage the learning regarding time. Effective time budgeting highly correlates with academic achievement.

According to Roberts and Erdos (1993), *meta-cognition* is a key concept in the study of cognition and it plays an important role in the transfer of cognitive skills and in problem solving. Meta-cognition refers to knowledge and cognition about one's own cognition. According to Treier (2004), meta-cognition is a kind of self-monitoring, self-observation, and self-regulation related to cognitive and information processing. Meta-cognition is the competence of reflecting a mental task critically and to organise involved learning and thinking processes in an efficient and effective way. The usage of meta-cognitive learning strategies is an essential component of SRL and is very important for flexibilisation and personalisation.

Taking into account the learner's characteristics by individually adapting learning methods has a big influence on the learner's performance (Issing 2002). The importance of the *adaptation* to the learner's characteristics (also called *personalisation*) was shown in several studies. For example, the adaptive subject material combined with adaptive styles of presentation supports students to improve their learning achievements and increases learning efficiency (Tseng et al. 2008). Furthermore, the importance of adaption to individual learning preferences of a learner regarding visualisation and verbalisation has been proven (Plass 1998). Through a requirement analysis it has been found out that the learner's knowledge, goals and tasks, language, interests, and learning styles are important factors of personalisation approaches (Hover and Steiner 2009).

Supporting SRL in the right way is a crucial factor. On the one hand, it means providing enough freedom for the learner, in order to stimulate motivation. However, on the other hand, too much freedom may be overwhelming and an appropriate guidance or even adaptation is usually needed to make the learning process effective and efficient. The concept of *guidance and freedom* is important because it has been recognised that highly motivated learners attain a better learning performance if they have more control over their learning and are more autonomous (Issing 2002). On the other hand, some learners show difficulties in carrying out concrete meta-cognitive activities, such as planning, goal setting, monitoring, evaluating, and as a result often perform less successfully than would be anticipated (Bannert 2006). Such learners are in need of guidance when learning. Furthermore, less motivated learners can also attain an improved learning performance if they receive more guidance. Keeping these reported findings in mind, the individual support for learners should be tailored to suitable degrees of guidance and freedom. In this respect, the learner should be offered an optimal and balanced level of control and autonomy for their own learning process.

Motivation is a highly relevant aspect for achieving good learning outcomes and for performing SRL activities. Winne and Hadwin (2008) showed the positive impact of motivation on student's attention to their learning progress, on the progress itself, and on the experience of satisfaction and positive affect. For the use of SRL activities, a learner has to be motivated as these activities require additional time and effort. Ryan and Deci (2000) describe intrinsic motivation as one of the most important aspects regarding learning because it is the prototypical manifestation of the human tendency towards learning and creativity. Behaviours of intrinsically motivated learners are freely applied without the necessity of separable consequences. For intrinsic motivation to develop, there is need for autonomy, competence, and relatedness. However, there is also a need for extrinsic motivation and especially a good balance between extrinsic and intrinsic motivation (Covington 2000)

Another important factor for SRL is *collaboration*. According to Dillenbourg (1999), collaborative learning comprises individually performed activities and also extra activities that are generated by interaction among peers. These collaborative activities trigger additional cognitive mechanisms, which may appear more frequently in collaborative learning situations than in individual learning. Students working in cooperative learning situations compared to individualistic or competitive learning situations have a higher performance at the mastery and retention of material, are more often using focusing, elaboration, and meta-cognition strategies, and develop ideas or solutions which are not gained if they work on their own (McConnell 2000). Collaboration can also create both intrinsic and extrinsic motivation and is an essential strategy for stimulating curiosity, emulation, attention, persistence, opening new perspectives, and increasing self-efficacy (Waite and Davis 2006).

All these aspects are relevant for the psycho-pedagogical approach of ROLE. The process model and related cognitive and meta-cognitive learning activities have been explicitly modelled. The concept of guidance and freedom as well as adaptation is achieved through recommendations of activities and resources. Other concepts, such as motivation and collaboration, are implicitly targeted through the use of technology.

Related Work and Technology

This section gives a short overview on technology-enhanced learning (TEL) solutions discusses them from the SRL perspective. Technology plays an important role for SRL because it has been reported that TEL environments can provide opportunities to enhance SRL competences for students, especially meta-cognitive competences (Bannert 2006).

Since the early 1970s, researchers have adopted the educational model of human tutors and started to implement it in intelligent computer-based instructions (Corbett et al. 1997). The goal of those *Intelligent Tutoring Systems* (ITS) was to engage students in learning activities and to interact according to their behaviour. ITSs were supposed to bring intelligence to computer-based instruction, especially in the knowledge of the subject domain as well as the tutoring principles and methods of their application (Anderson 1988). This led to the development of four basic components: the domain model, the student model, the tutoring model, and the user interface model. An important research strand is also the work on adaptive hypermedia and adaptive Web and how it is applied in the educational context (Brusilovsky et al. 2007). Strategies and systems (e.g. as described in Albert and Schrepp (1999) and DeBra et al. (2006)) have been developed that aim to adapt its content and behaviour to the individual student. In the light of SRL, these solutions do not support the learner. They do not allow freedom or autonomy, but guide the learner through the learning process. They also do not give any hint or explanation regarding SRL.

A different development of TEL solutions is *Learning Management Systems* (LMS). They primarily focus on distributing learning content, organising the learning processes, and serving as interface between learner and teacher. In educational institutions LMSs have become very popular and are used in many universities and schools (Paulsen 2003). Examples of LMSs are Moodle, CLIX, Blackboard, WebCT, Sakai, ILIAS, and LRN. They all have in common that different tools are integrated in a single system, such as discussion forums, file sharing, whiteboards, chat, and e-portfolios (Dalsgaard 2006). These tools together with learning content are bundled by teachers or tutors, leading to a centralised and standardised learning experience (Guo et al. 2010). In contrast to ITSs or adaptive systems, no automatic guidance is provided by LMS. The guidance the learners get is provided by teachers or instructors who prepare courses. On the other hand, learners have more freedom and autonomy through some tools integrated in LMSs. For example, collaboration tools allow to discuss certain topics.

In contrast to an LMS, *personal learning environments* (PLEs) strive for a more natural and learner-centric approach. PLEs are online systems that combine services as well as tools that enable users to create their own customised learning system. The teacher is no longer the provider of knowledge, but rather a mediator between knowledge and students. On the other side, the student is responsible for organising information and their own learning. In recent years, attempts have been made to build PLEs based on mashup designs. An example based on social media tools is eMUSE (Popescu and Cioiu 2011), which integrates Web 2.0 tools into a single system. It claims that such tool integration leads to a sense of community and thus increases success and retention rates. Furthermore, eMUSE offers support for self-monitoring and self-evaluation by providing feedback on learning tasks, which is supposed to increase learning success and motivation. A further example is the PLE developed at the Graz University of Technology (Ebner and Taraghi 2010). This PLE allows for selecting widgets from a repository and adding them to a personal space. Besides some general purpose widgets (similar to the tools in an LMS), domain-specific widgets have been created by students in university courses. It also allows for logging and analysing students' activities performed on these PLEs (Softic et al. 2013). Users can manage their PLE and, therefore, take greater control of their own learning approach.

Specific technology that aimed supporting SRL was developed in several research projects. For example, the iClass project aimed at developing an intelligent, cognitive-based open learning environment that supports the planning, monitoring, and reflection processes of a learner and at the same time personalise the learning process to the respective learners' preferences and needs (Aviram et al. 2008). In order to achieve personalised recommendations and reflection support, a competence model has been used that is basis for individual guidance (Steiner et al. 2009). This competence model is based on Competence-based Knowledge Space Theory (CbKST) (Heller et al. 2006) that structures competences through prerequisite relations. Visualisation tools have been created that display the competence structures and let the learner select learning goals and learning paths (Nussbaumer et al. 2008).

The ROLE approach differentiates from these solutions in the way that it provides a maximum of technical flexibility and provides personalised learning support at the same time. A psycho-pedagogical model is integrated with the technology, which leads to range of freedom and guidance to be chosen by the learner.

Models and Framework

Self-Regulated Learning Process Model

A process model (Fruhmann et al. 2010) has been developed that takes into account requirements of the ROLE approach to create and use responsive open learning environments that support SRL. The SRL process model describes learning as a self-regulated process consisting of four learning phases: (1) defining or revising the learner's profile information and setting up an initial individual learning plan, (2) finding and selecting learning resources, (3) working on selected learning resources, and (4) reflecting on the applied strategies and reached achievements. The model is depicted in Fig. 1. This approach follows the cyclic SRL model proposed by Zimmerman (2002) and was slightly extended and modified. First, the

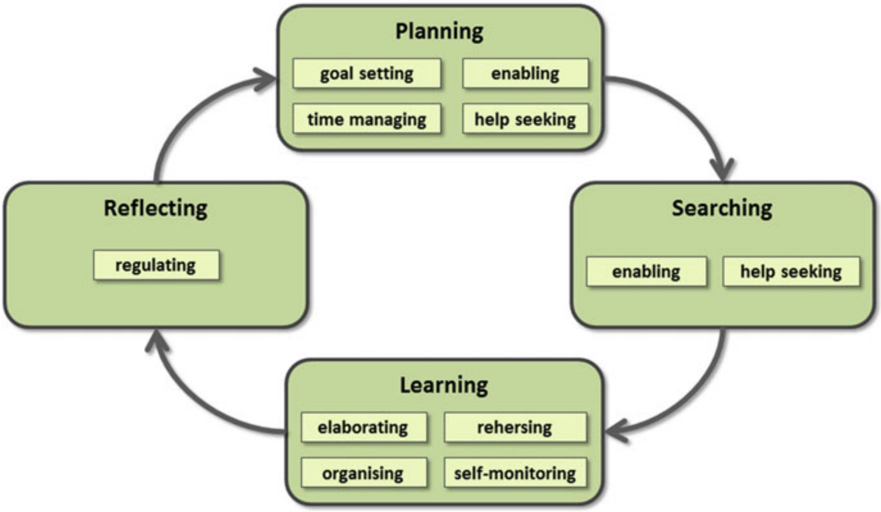

Fig. 1 SRL process model. This diagram depicts the SRL process model and related strategies

phase when learners create their own learning environment is considered as a separate phase because this is a central part of ROLE. In the Zimmerman model this phase would be related to the forethought phase. Second, the personalisation aspect has been included by defining a user model consisting of models for describing competences, learning activities, and goals.

In addition to these phases, a taxonomy of learning strategies, learning techniques, and activities has been defined, in order to operationalise the four phases. The phases are associated with learning strategies (see Fig. 1) and each strategy is related to learning techniques and learning activities. We consider learning activities as the applications of learning techniques. This approach is based on the work of Dabbagh and Kitsantas (2004) on SRL processes and Mandl and Friedrich (2006) on SRL strategies and techniques. These findings have been adapted and integrated, in order to serve as a comprehensive and integrated model for technology-support.

Using this theoretical background, we have defined nine SRL strategies and structured them in three groups, which are cognitive strategies, meta-cognitive strategies, and resource management (see Fig. 2). The group of cognitive strategies include organisation, elaboration, and rehearsal tasks of learning topics. The group of meta-cognitive strategies include goal setting, self-monitoring, and regulation tasks targeting the control of the own learning process. The group of resource management strategies include time management, help-seeking, and enabling (or environment preparation), which means that learners take care for their learning resources. These strategies are connected to SRL phases, which enrich the meaning of these phases with a clearer notion. For the instantiation of learning strategies and learning techniques, two complementary approaches have been used.

For each of the nine listed learning strategies, a variable number of learning techniques are assigned. For instance, elaboration can be done with the following

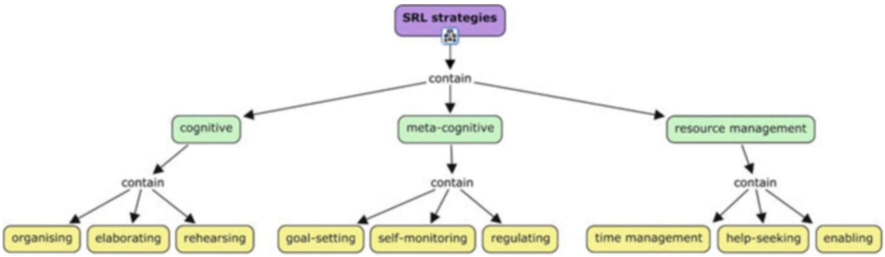

Fig. 2 SRL Strategies. This diagram displays the SRL strategies and their relations to each other

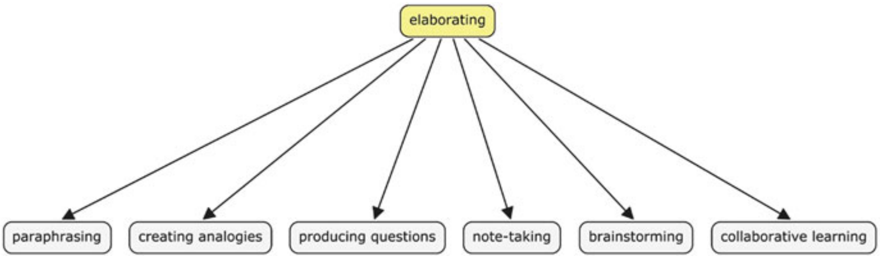

Fig. 3 SRL techniques. This diagram gives an example of an SRL strategy and six associated learning techniques

learning techniques: paraphrasing, creating analogies, producing questions, note-taking, brainstorming, and collaborative learning (see Fig. 3). A complete list of learning techniques and their assignment to the SRL strategies can be found in the ROLE ontology (see section "Learning Ontology").

Applying the SRL Process Model

Using ROLE learning environment learners are interacting with a learning environment that provides various resources like contacts to other actors, appropriate tools/services, and suitable artefacts for the acquisition of knowledge, skills, and the fostering of competence development. For the personalisation and the preparation of a learning environment, learners have to set up their learning space in a meaningful. Especially in SRL situations, where learners take responsibility for the learning process and learning outcomes, the competent application of learning strategies is considered helpful for learners and can lead to better learning performance (Weinstein et al. 2005).

In SRL situations the definition of the learning goal before the selection of learning tasks and the application of learning activities is very important. If learners

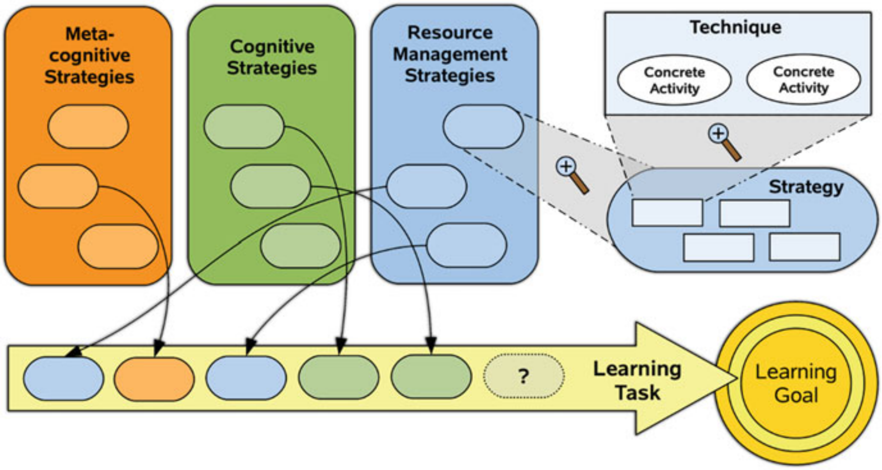

Fig. 4 Applying SRL strategies and techniques. This figure explains how SRL strategies and learning techniques are applied in the learning process to achieve a learning goal

are not aware of their learning goals and if they do not know how to reach them, learners incline to apply more or less habitual learning strategies that may not be appropriate for processing a learning task instead of adapting or making up new strategies. The SRL process model and the related learning strategies and techniques are used to guide the learning through the learning process (see Fig. 4). First learners set a goal. Then they choose from a set of cognitive, meta-cognitive, and resource management strategies. The strategies are related with respected learning techniques and learning tools. In this way a sequence of learning activities (strategies and techniques) is created that should lead to reach the learning goal. Through recommender systems (see section "Support Strategies") the learner can get help during the selection process.

Competence Model

A competence model consisting of different kinds of competences takes into account domain knowledge, the ability to learn with tools, and SRL competences. The distinction of the competence types originates from the fact that learning happens on different levels. We distinguish between (1) domain knowledge and related competences, (2) the ability to learn with specific tools, and (3) the ability to learn in a self-regulated way. Therefore, three types of competences are defined: domain competences, tool competences, and SRL competences.

The domain competence describes the knowledge of a learner regarding a certain domain-specific topic. In detail a concept (e.g. from a concept map) is assigned with a level from the European Qualifications Framework (EQF).[3] The tool competence defines the ability how a learner can apply a learning technique with a certain tool functionality. Formally spoken, a tool competence is a pair of a related learning technique and an EQF level. For example, it can be defined how well a learner can debate with a tool that allows for video conferencing. The SRL competence defines the ability regarding one of the nine learning strategies described above.

Learner Model

In adaptive systems, user models are often designed as overlay models where user information relies on and is described by conceptual information (e.g. concept maps). Our learner model follows this scheme, but also relies on the learning taxonomy and its elements. This is necessary as the information about the learner is not only given at domain level, but also on the level of cognitive and meta-cognitive activities (the application of the learning strategies and techniques). The learner model consists of four elements. First, the competence state describes the available competences of the learner taking into account that there are three different types of competences. Thus, a learner is assessed regarding domain knowledge, the ability to learn with tools, and the ability to learn in a self-regulated manner. Second, the goals of a learner are also described with these competences, e.g. the learning goal is expressed in terms of the competences a learner wants to achieve. Third, the learning history is described by the learning activities (applied strategies and techniques) a learner has performed, the tools or widgets she has used, and the competences she has attained. In contrast to plain log data, this learning history provides more insight because it describes the history in terms of learning not just the particular interactions, but also regarding learning activities and used resources. Fourth, pedagogical parameters describe individual preferences and properties of the learner. Examples are information about preferred tools, learning groups, or guidance mechanisms. An overview is given in Fig. 5.

[3] http://ec.europa.eu/education/lifelong-learning-policy/eqf_en.htm

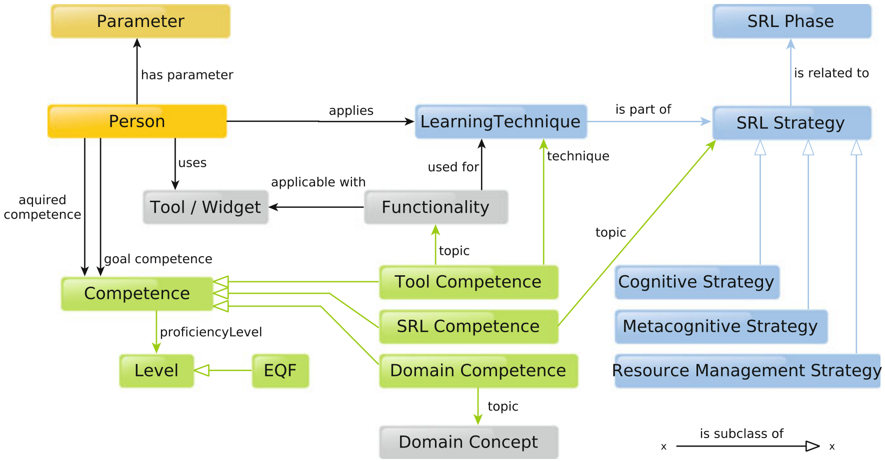

Fig. 5 Competence ontology. This diagram depicts the relevant elements of the competence model and how they are technically interrelated

Learning Ontology

The formal representation of the models listed above (competences, strategies, techniques, goals) is expressed as ontology in RDF[4]/OWL[5] format and consists of the classes and properties. An overview of this ontology is depicted in Fig. 5. More details on the learning ontology can be found in Dahn et al. (2013). The *Competence* class is the superclass of the three types of competences. It allows specifying title and description via reusing the title and description properties from the Dublin Core[6] terms vocabulary. Furthermore, it provides two properties that allow for a generic definition of the competence. First, a *topic* property is used to relate a specific competence with a generic object (*owl:Thing*). Secondly, the *proficiencyLevel* property is used to express the extent to which a user has a specific competence. The generic *Level* class is subclassed by the *EQF* class to indicate the competence level.

In order to relate a competence to a learner, a *Person* class is used that has the properties *acquiredCompetence*, *goalCompetence*, *uses*, *applies*, and *hasParameter*.

In this way competences are defined that a learner has already acquired and competences that a learner should attain, the tools a learner has used, the learning techniques she has applied, and the personal preferences. The *DomainCompetence* class allows for defining a domain competence. It is a subclass of the *Competence* class and inherits *title*, *description*, *topic*, and *EQF* level specification. In this way

[4] http://www.w3.org/RDF/

[5] http://www.w3.org/TR/owl-overview/

[6] http://dublincore.org/

competence can be defined by using the *topic* property to assign the related domain concept and the *proficiencyLevel* property to define the EQF level. The *ToolCompetence* class allows for defining a tool competence. It is a subclass of the *Competence* class and inherits the title and description specification. Following the definition of tool competences, the topic property is used to relate tool functionalities and the technique property is used to relate a *LearningTechnique*. The *SRLCompetence* class allows for defining SRL competences. It is a subclass of the Competence class and inherits the title and description specification. Following the definition of SRL competences, the *topic* property is used to relate to SRL strategies and the inherited *proficiencyLevel* property is used to relate an EQF level. Since SRL competence can be related to different types of SRL strategies (cognitive, meta-cognitive, and resource management strategies), appropriate subclasses of the *SRLStrategy* class have been defined.

Mashup Guidelines

The mashup of a learning environment is an important feature. It can affect the way of learning not only by its pure use, but how it is compiled. It is assumed that compiling widgets to a learning environment or bundle relate to different psycho-pedagogical aspects and educational components. Taking into account these educational components, some essential guidelines have been developed to provide the learner with recommendations for a psycho-pedagogically sound mashup (Berthold et al. 2012). These guidelines should be taken into account by the learner creating a bundle for herself and by teachers or tutors creating bundles for learners. It is also a basis for recommender technology that can apply these guidelines.

Guideline 1: Cover all phases of the SRL process model: As described in section "Theoretical Background", learning is more successful if different cognitive and meta-cognitive strategies are applied. Hence, a mashup design should contain widgets that support different learning strategies. For example, one widget for each phase of the SRL process model. This could be materialised in a setting with a widget for goal setting, a widget for content searching, a widget to learn how to find content, and a widget where the learning process is reflected.

Guideline 2: Tool competence: Another educational component that comes into play is tool competence. Tool competences are abilities a learner has if she has knowledge about a tool, is able to perform a learning activity with a learning tool in a domain or domain-independent context, and is able to choose a tool or tool functionalities unassisted according to her learning or working task, e.g. the learner can use a tool for goal setting. If a tool competence is lacking for a certain widget, the learner will have problems to effectively use this widget.

Guideline 3: Number of widgets: The number of widgets and their different functionalities might overtax the learners, especially if they are not intrinsically motivated to perform the learning task. Hence, only an appropriate number of widgets should be added to a widget bundle. The range of the appropriate number of widgets within a widget bundle depends on the learner.

Guideline 4: Domain aspects: In the third phase of the SRL process model, the actual learning process takes place. This phase is influenced by learning goals. Learning goals are defined in the first phase of the SRL process model. Such learning goals are mostly domain specific and refer to a special context. Thus, widgets in the bundle should be in line with the domain aspects of the predefined learning goals.

Support Strategies

In the previous section it has been described how SRL can be operationalised. In this section concrete approaches are reported how SRL is supported by using the models and framework described above. They establish the ground basis for the technology and concepts to support learners in a scientifically driven way and provide learners with according technology and material to guide them through the learning process.

Learners who are able to understand the SRL process and the related learning activities and who are able to perform them on their own can navigate freely through their learning processes. However, this requires the availability of a high degree of SRL capabilities (availability of the respective SRL competences). Since it cannot be assumed that all learners already have these abilities, guidance mechanisms are needed. Such guidance is often needed especially when learning with technology-enhanced environments (Bannert 2006).

According to the experiences made in the test beds and at several workshops (see section “Related Work and Technology”), a variety of guidance strategies is necessary. Both technical and human support is needed depending on the learner and the situation. Additionally training and introductory material turned out as useful to increase initial motivation for new ways of learning.

Motivational Video

This section explains an initiative to make learners acquainted with SRL. According to our experience (in test beds and SRL surveys), the concept of SRL is new to most lectures and learners. Lifelong learning, non-formal learning, etc. are buzz words society talks about, but SRL is apparently a term more common in science and pedagogical research. For this reason, SRL needs to be introduced and actually promoted to learners, teachers, and a broader community to point out benefits of such a learning approach. An introduction can be done in many different ways.

Fig. 6 SRL video. This figure is a screenshot of the video that introduces and explains SRL in the context of ROLE

Teaser videos were used to explain the concept of SRL on a basic level for learners who are completely new to SRL. A video[7] has been created that focuses on the explanation of SRL by comparing it to a city travel (see Fig. 6). Two people are examining a city and its sights. While the first one is attending a guided tour, the second one defines the goals and plans on his own and does a city walk without external support. This analogy is explaining both the concept of self-regulation and the concept of guidance. Further videos have been developed in the course of the ROLE project, in order to explain different aspects of PLEs and SRL[8]. Especially, tutorial videos have been created that explain how to use ROLE technology.

Courses and Training Material

An SRL course is another method to reach learners and provide them with assistance and knowledge about SRL and SRL tools in a compact way. The goals of such a course are to introduce the idea of SRL and enable them to build their own learning environment. The content of such a course can be a brief SRL explanation, an explanation of different learning models or learning strategies, and how they can be used with ROLE technology.

At the Open University UK test bed such a course has been created as Online Course and as eBook. This course explains the basic concepts and also lets learners

[7] http://www.youtube.com/watch?v=jTa1vOH6JjA

[8] https://www.youtube.com/user/ROLEProject

try out to create PLEs on their own. In this way learners can train SRL behaviour because they get step-by-step explanation and can try it out immediately.

Preconfigured PLEs

Predefined PLEs are already compiled bundles of widgets to fulfil a certain learning need. Therefore, they are usually assembled with widgets that cover a certain domain (e.g. history, chemistry, or language learning). Such bundles are typically created by teachers or peers. Teachers have the chance to prepare a bundle suitable for the learning topic. In this way, the guidance is based on the preparation of whole bundles that are suitable for individual learners. A special case is Layered PLEs that consists of a set of widget bundles. Each set may be dedicated to a certain learning strategy of an SRL process phase.

Widget Store

The ROLE Widget Store is a Web-based online catalogue that allows to manage and index widgets. It provides a user-friendly interface to a widget repository that simplifies the discovery of widgets. The functionality of the widget store includes listings of widgets, categorisations, searching by widgets or keywords, and compilation of widgets into bundles. Users can add widgets from the widget store to PLE systems. From a social media point of view, the store is also the place to collect and share user tags, comments, and ratings. A widget creator and developer can add a widget to the store by adding its reference (URL) and metadata.

In order to provide guidance for learners in searching and selecting widgets for their PLEs, widgets can be tagged with metadata describing the purpose of the widgets. The first type of tags is a widget categorisation consisting of seven categories. The categories were derived from the SRL learning process model and are assigned to its phases. As described above a PLE should consist of widgets not only for one learning strategy, but widgets for different strategies should be included. The categorisation system is a useful way to follow this guideline because users get quick access to widgets for the specific purposes. They can browse the store and add widgets just by navigating to different categories.

In addition to the widget categories, functionalities described in an ontology are used to represent features of widgets (e.g. text editing, video chat). These functionalities are derived from a survey of existing widgets and from an analysis of the ontology. The SRL techniques are related to functionalities so that the ontology and the Widget Store share the same set of functionalities.

The third type of metadata is the domain concept describing widgets regarding a knowledge domain they are related to. Widgets can be either generic (e.g. text editor) or targeting specific learning domains (e.g. French language). As some widgets can hardly be described by tool categories or functionalities alone, a categorisation based on learning domains is introduced. The service of DBpedia[9] is used to allow users the tagging of widgets by semantically unique learning domains supporting them in search for specific tools.

The user interface of the Widget Store allows for searching and filtering widgets according to categories, functionalities, and domain concepts. A list of widgets is listed according to the applied search. Additional filters can be applied regarding the metadata available for the listed widgets. The metadata for each widget is shown in the search result list, that is, category, functionalities, domain concepts, rating, title, and description.

Mashup Recommender

The Mashup Recommender widget (MR) (Fig. 7) can be seen as a filtering system that provides widgets that can be added to the PLE depending on the used template. The MR contains predefined templates, e.g. an SRL template. This template could include the four phases of the SRL process model. If the user selects such a phase, related widgets that support this phase are displayed. For example, if the learner selects the planning phase, calendar widgets, and To-Do-Widgets could be suggested by the MR. For this purpose, the MR uses SRL entities from the

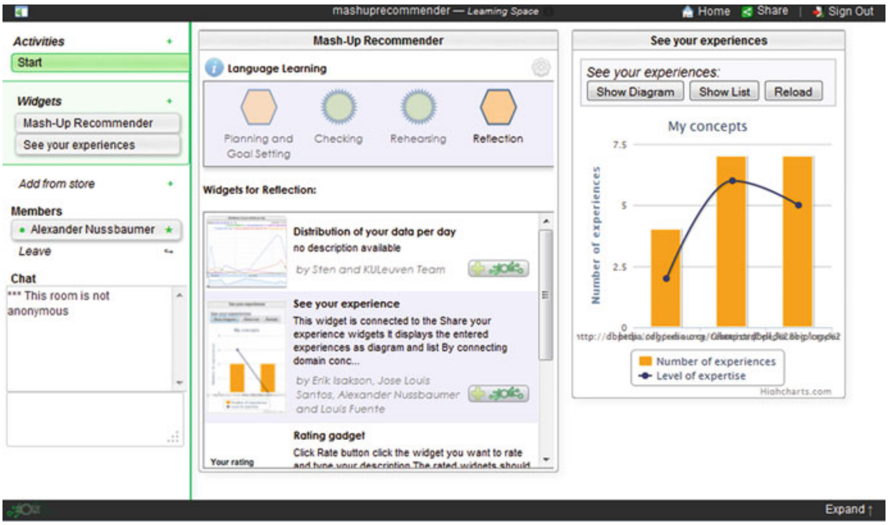

Fig. 7 Mashup Recommender. This screenshot displays the Mashup Recommender widget in the middle and a widget that was recommended on the right side

[9] http://dbpedia.org/

ontology. The ontology service is questioned for the respective functionalities of the SRL entities (learning strategies, techniques, and activities) and the widget store returns the associated widgets. Such templates can be created using a special authoring tool.

The MR can be used to provide guidance on different levels and for different stakeholders. A high level of guidance is the preparation of complete predefined PLEs based on a specific template by a teacher or tutor. Later the tutor can share this PLE with her students who can use it or modify it. A lower level of guidance can be provided if the teacher just shares the template with the students, so that they have to create their own PLE. For example, a teacher could select the SRL entities goal setting, resource searching, note taking, and reflecting for a template. Teachers or learners using this template could easily search these SRL entities for widgets and include them in a PLE. In this way the PLE consists of widgets for each SRL entity. Learning strategies are on a higher abstraction level, which results in a greater number of widgets that can be recommended. Learning techniques are on a lower abstraction level, which leads to a smaller number of related widgets that can be recommended. While in the first case the learner gets more widgets recommended and thus less guidance, in the second case the level of guidance is higher because of the smaller number of recommended widgets. For a detailed description of the MR and its technical background, see Nussbaumer et al. (2014).

Activity Recommender

The Learning Activity Recommender guides the learner through the learning process by recommending learning activities related to the SRL process model. The learner is guided by means of a step-by-step approach of how to cope with a problem. In contrast to a direct instruction, the learner can decline to accept learning activities and can choose between alternatives and will not be penalised for varying his learning steps from what is suggested. The Activity Recommender (AR) consists of two widgets, the Activity Recommender widget and the To-Learn List widgets (Fig. 8).

In contrast to collaborative and content-based filtering approaches handling large community-generated data sets, the Activity Recommender is working with data predefined and structured by the educational experts according to the educational approach described in the last section. These experts prepare the recommendations by defining learning strategies, techniques, and matching activities for learning tasks using an authoring tool. The Activity Recommender guides the learners through the learning process by recommending learning activities and assists them to compile a learning plan. In contrast to direct instructions, the learners have a free choice which recommended learning activities they want to perform. When a learner has decided to use a recommended learning strategy, the respective learning activities can be sent from the Activity Recommender to the To-Learn list widget. The To-Learn list widget allows learners to compile an individual learning

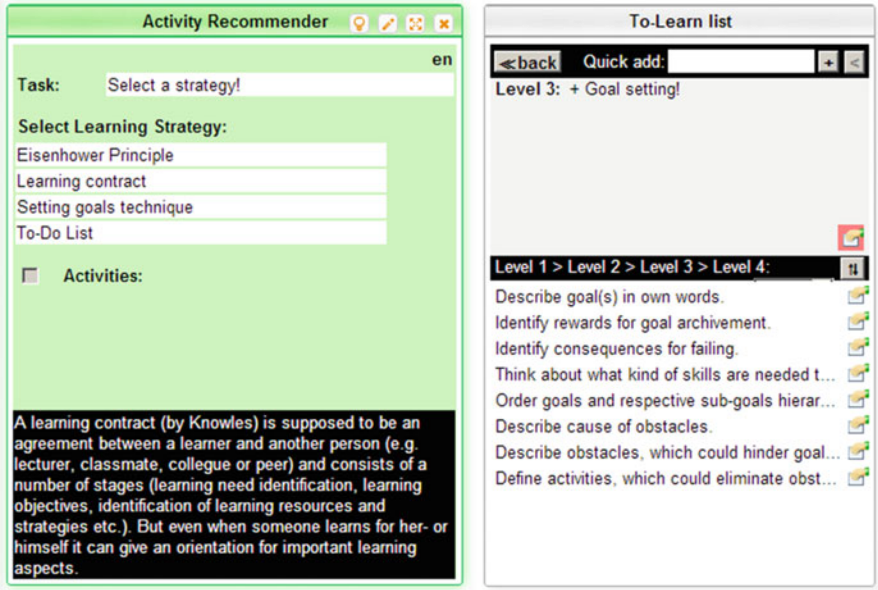

Fig. 8 Activity recommender. The To-Learn List widget and the Learning Activity Recommender widget are running in the ROLE SDK environment

plan. The widget enables to add, rearrange, delete, and rename recommended learning activities or to add own activities, e.g. reminding them to take a break after a brainstorming session. A learning activity is described with a short summary and a longer descriptive text. Every learning activity has a status that is either *not started*, *started*, *completed*, or *cancelled*. Moreover, it is possible to specify the learning activities by adding sub-activities on the lower hierarchy levels. Some of the activities are highlighted in red colour, which means there are further recommendations available for this activity. Displaying these recommendations can be triggered by clicking on a highlighted entry. Finally, the entries of the learning plan can be sorted by status, date, or manually.

SRL Text Reader Bundle

The SRL Text Reader Bundle (see Fig. 9) is a predefined widget bundle that supports SRL by providing feedback on the SRL activities. The bundle captures certain SRL activities and displays them in a graphical way to make the user aware about the activities she performs. The main widget is Text Reader where learners can read and annotate texts. These texts and related concepts are defined in a domain model on a backend service. The Self-Evaluation widget allows for relating the assigned tags with concepts from the domain model and to determine the proficiency level for each concept. In this way, the learner evaluates herself

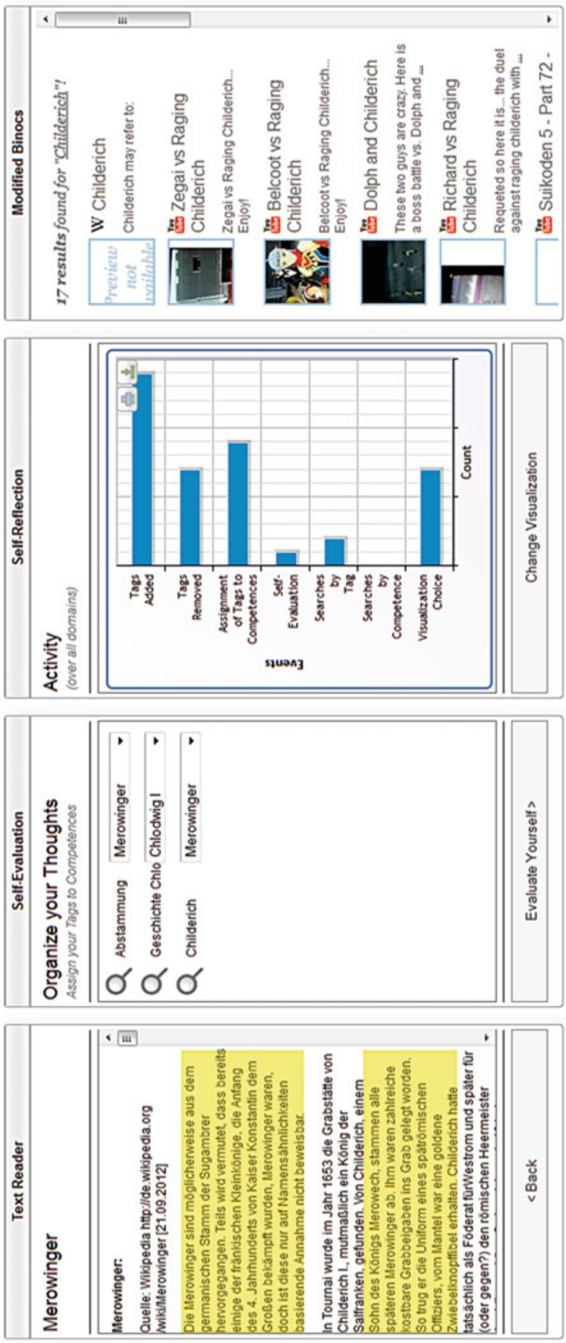

Fig. 9 SRL text reader widget bundle. The four widgets are displayed in this screenshot

regarding her own domain competences. The search widget allows searching additional resources for the domain by searching related tags and concepts. All performed activities are recorded and stored in the user model. The visualisation widget follows an Open Learner Model approach and gives feedback to the learner about her learning process. In addition, the visualisation widget displays the texts that have been annotated and the concepts that have been used for self-evaluation. Guidance is provided by delivering a complete bundle of widgets that support the whole SRL process.

From the user model perspective some different types of information is saved for further usage. The activities a learner performed are saved using the activity schema outlined in the ontology definition in section "Support Strategies". The concepts coming from a domain model in the background and used for self-evaluation are stored together with the proficiency level as domain competence. The tags related to certain texts are saved as generic information. All this information is used for keeping the user data persistent and visualising the analysis in the Self-Reflection widget.

SRL Monitor

The SRL monitor provides support to develop self-awareness about the performed learning activities. The goal is not only to monitor and visualise the observable actions (as saved in log data), but also to monitor the cognitive and meta-cognitive activities that are not directly measurable. To this end, the measurable actions are mapped to cognitive and meta-cognitive learning activities from the ontology. To be precise, the key actions extracted from the log data analysis (based on an algorithm that clusters the log data) are mapped to elements of the learning ontology. The mapping is partially done by the learner herself, but also supported by an algorithm that takes into account the previous manual assignments. The goal is to make learners aware about their cognitive and meta-cognitive learning activities.

The screenshot displayed in Fig. 10 shows two views of the SRL Monitor. In the first view, the SRL Monitor displays the learner's captured log data in a sequence. Then the learner can select which learning technique she has actually applied. Based on these selections, reasoning is done regarding the applied learning strategies. Since there are only nine learning strategies, a comprehensive overview of the learner's behaviour can be given. This overview is graphically shown in the second view of Fig. 10. In this way learners get feedback about their learning behaviour and might rethink their learning process if some learning strategies never appear on the graphical profile.

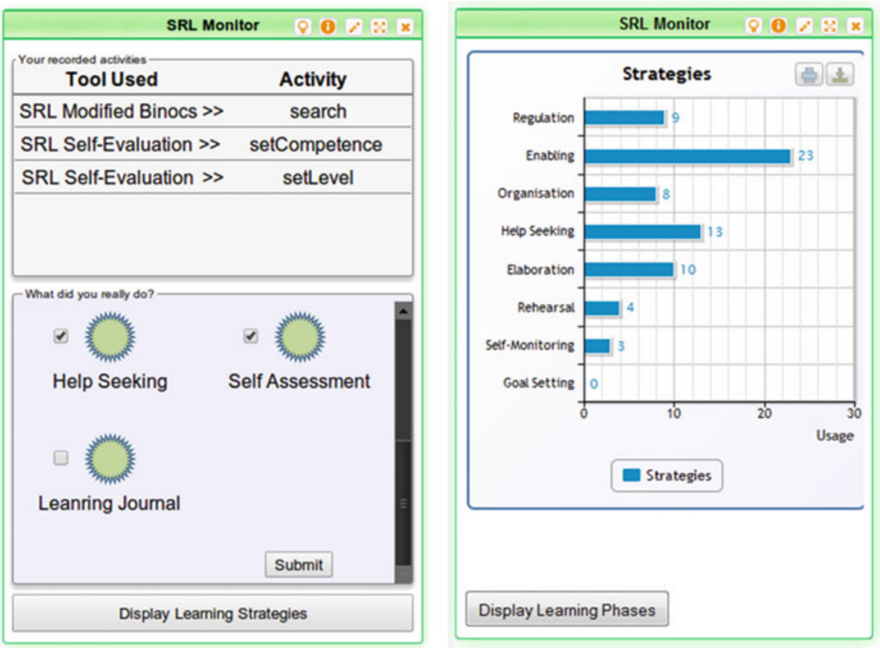

Fig. 10 SRL monitor. Screenshots of the two views of the SRL monitor widget are shown

Evaluation Results, Challenges, and Barriers

This section gives insight in the experiences made with the psycho-pedagogical model and the support strategies described above. It starts with an overview of evaluation studies of a few support strategies. Then it describes the experiences made in the test beds, in summer schools, and at conference workshops. More detailed evaluation results are described in the Chaps. 4–7 of this book.

Selected Evaluation Results

One evaluation study (Kroop 2013) focused on the usefulness of the developed Mashup Recommender (MR) widget (see section "Mashup Recommender", Fig. 7) and the SRL template it provided. The study compared teachers' and students' acceptance for the MR and its underlying SRL strategy. Altogether the findings show a broad acceptance of the MR concept by both teachers and students. When a group of teachers and a group of students independently from each other tested a variety of PLE-scenarios, the MR was recognised to be the only tool which consistently supports the creation of a PLE in a self-regulated learning way. Most scenarios for creating a PLE provide too much freedom (especially in selecting relevant learning tools from a broad variety of open educational resources), which causes students as well as teachers to be exhausted easily from (individually) evaluating and selecting learning tools. Consequently, the provided SRL guidance by the MR was perceived as a relief in creating a PLE. Although neither the teachers nor the students already felt familiar with the MR widget, teachers and students independently from each other appreciated the well-conceived idea to support SRL while creating a PLE. The discussions as well as the final ratings of the MR concept revealed that teachers were even more optimistic than students regarding the potential of the MR concept to improve and ease (self-regulated) learning. The findings of this study confirm the findings of the below described TPSRL study: Not only do students need guidance how to learn self-regulated but it is also important to provide support to the teachers and to train them how to (efficiently) introduce SRL to students. Another study (Dahn et al. 2013) concerns the Activity Recommender (AR) (see section "Activity Recommender"). The objective of this evaluation was to uncover strengths, weaknesses, and suggestions for improvement of the proposed approach and implementation. Therefore, usefulness of the learning support, usability of the developed software, and general feedback were questioned. The evaluation has been conducted in two different settings: The first evaluation took place in at the University of Koblenz-Landau in Germany and the second evaluation took place at the Shanghai Jiao Tong University in China. Summarising the results, there was a clear indication that the students appreciate guidance and help during the learning process. Some of the students liked the idea of getting recommendations for learning strategies and techniques for improving their learning. However, some students did not understand that recommendations are suggestions and not "must-do" instructions. Usability turned out as being the weakest point of AR. Without supervision and human support, many students had difficulties with the proper usage of the AR. Concluding these results, the approach of recommending learning activities is useful for and appreciated by students, whose SRL competences are not very low, but who do not apply SRL activities during their learning process. However, very weak self-regulated learners need sound introduction to SRL not only on pure technological level, but also in terms of human explanation, an introductory course, or videos.

Results from the Conference Workshops

The workshop series at the ICALT conferences in 2011[10] and 2012[11] aimed at investigating SRL in personal learning environments. The target audience consisted of researchers, developers, and users of learning environments who were interested

[10] http://dbis.rwth-aachen.de/SRL-ROLE2011/

[11] http://dbis.rwth-aachen.de/S-ROLE2012

in building individual learning environments. The accepted papers were presented at the workshop and published in the ICALT conference proceedings. The presentation session was followed by a group and plenary discussion.

The interactive format of the workshops helped to identify barriers of SRL. According to the participants, these barriers are mainly in the traditional educational system that does not cultivate the self-regulation competences early enough. This system designed for industrial purposes does not suit modern requirements anymore, as it kills motivation and creativity in learners. Individualisation of learning is a major challenge in education and rapid technological development brings new opportunities how to address it. A good SRL solution should be personalised and adaptive, providing a right balance between the learner's freedom and guidance, in order to both motivate and support the learner. This threshold is individual and context dependent. Therefore a spectrum of facilities is needed for various levels of SRL at different levels of education and in different contexts. Another key challenge is to prepare learners for lifelong learning when the teacher may not be available. They have to learn meta-cognitive skills, which are highly important. In this process, suitable scaffolding has to be taken into account.

The PALE workshops at the UMAP conferences in 2011 and 2012 provided opportunities to identify and discuss various issues related to topics like pedagogic conversational agents, responsive open learning environments, and learner modelling.

At PALE 2011[12] (Perez-Marin et al. 2011) the ROLE-related discussions focused on the usefulness of PLEs in order to support SRL. A big challenge is to find an appropriate threshold between the learner control and tutor guidance. Personalised support can be provided by means of design templates and recommendations. In any case, this support has to be effective but not intrusive, considering the learner preferences. Moreover, these preferences are not static, but can change dynamically according to the context. Participants suggested focusing the research on two scenarios where learners are supposed to have certain capabilities to guide themselves: higher education and lifelong learning. It was also suggested to consider meta-cognitive competences as well as results of behavioural and cognitive psychology when designing learning environments.

To summarise the outcomes from PALE 2012[13] (Herder et al. 2012), a lot of data can be collected in the educational process, but we need to find ways how to use it reasonably and to develop useful services that make the learning process more effective and efficient, e.g. by predicting student outcomes in order to intervene. Novel personalised services and environments are needed especially in lifelong and workplace educational settings, in order to support informal, self-regulated, mobile, and contextualised learning scenarios. A big challenge is also adaptation considering both long-term objectives and short-term dynamically changing preferences of learners. Here, open and inspectable learner models play an important role,

[12] http://adenu.ia.uned.es/workshops/pale2011/

[13] http://adenu.ia.uned.es/workshops/pale2012/

considering also learner motivation and affective state. In the case of pedagogic conversational agents, personalisation is fostered by the use of dialogues adapted to the specific needs and level of knowledge of each student. Here and in mentorship systems trust and reputation play a crucial role.

At AHA 2012[14] conference in Vienna a ROLE workshop[15] on PLEs and the support of SRL took place. Workshop participants were mainly teachers and professors from Germany and Austria but also school consultants and technical support people from higher education institutions. At this workshop the participants had the opportunity to test and discuss a variety of ROLE tools for creating a PLE including tools for supporting SRL when creating a PLE. This workshop-session as well as an additional cross-validation workshop with students including teacher candidates from the University of Vienna revealed and confirmed success criteria as well as limitations and barriers for the uptake of the provided ROLE tools. The workshop results which explicitly included the perspectives and backgrounds of German-speaking countries and cultures were also presented and discussed with professionals from Guatemala at a Workshop on Cloud Education Environments (WCLOUD 2012) in Antigua, Guatemala (Kroop et al. 2012). Interestingly the experts from Guatemala shared the perspective of their colleagues from German-speaking countries, especially the need for SRL-supporting technology.

The essential success criteria for the uptake of the PLE tools were seen in the underlying pedagogical learning model: While participants were working with the provided tools and felt sometimes overwhelmed by the challenge to create a reasonable PLE, it became clear that a consistent model on SRL strategies and techniques as described in section "Models and Framework" was most needed. The idea to connect different stages of SRL (Planning, Searching, Learning, Reflecting) with corresponding ROLE tools for learning was seen most useful and most effective by almost all participants. A positive impact on learning by using SRL-supported PLE tools was especially seen in the following learning activities:

- Getting started with a learning task in a meaningful way.
- Keeping track of the own learning progress by following the provided learning strategy.
- Improved time management and reflection. Limitations for the uptake of the provided ROLE tools as well as doubts on the learning improvement by using these SRL-supported PLE tools were assumed as well and mainly addressed the personality, attitude, and motivation of a learner:
  - Motivated learners will benefit from the provided PLE tools; it will improve their efficiency and outcome of learning.

[14] http://ahakonferenz.at/fruhere-aha/aha-2012/

[15] Sylvana Kroop, Marcel Berthold: Personalisierte Lernumgebungen. Unterstutzung von selbstreguliertem Lernen.

- Very motivated learners will not need the technology-based SRL-support (e.g. the Recommender Widget, see section "Mashup Recommender", Fig. 7).
- Less motivated or weak learners will not benefit from the provided PLE tools.

Unfortunately the last assumption (about weak learners) was not well reasoned by the experts. But from the discussion context, it can be assumed that an intrinsic motivation of a learner is seen as a prerequisite to be successful when learning with PLEs. The idea that SRL-guidance provided by the PLE technology could trigger the motivation which is missed by weak learners was received with reservation.

Crucial barriers especially teachers raised for the uptake of the provided ROLE tools were belonging to time-consuming concerns for (learning) activities such as:

- To get in general used to the new PLE technology.
- To create a useful PLE in order to use it for the content taught in school and for the most ambitious request.
- To create and provide own SRL templates (see section "Mashup Recommender") which are adapted to a specific course or specific learning content.

Time-related issues in general can be seen as typical criteria for the uptake of any new technology. However, interesting is the fact that the participating teachers were aware of the possible time-wise burden and the additional effort compared to their used traditional learning and teaching but still accepted the uptake of the provided ROLE tools. They explicitly recommended the SRL-supporting PLE tools. Moreover, at the end of the workshop the involved teachers strongly expressed their wish to try out a PLE in their daily activities and thus created a mailing list in order to be informed and provided by further material, tutorials, online courses, or upcoming workshops on this topic. Altogether the experiences and findings from workshops gave important directions for the request and need of the research and development of innovative learning technology.

Lessons Learned from the Test Beds

Within the ROLE project, an instrument for understanding the perceptions of educators about SRL was devised. A questionnaire called "Teachers' Perception of Self Regulated Learning" (TPSRL[16]) was formulated, containing questions about how teachers perceive the SRL capabilities of their students, as well as about the challenges associated with teaching students with varied SRL competences. This questionnaire was circulated among the teachers of the Higher Education ROLE test beds. The TPSRL survey set out to explore which factors potentially influence teachers' assessments of their students SRL competence, how they see the

[16] http://fit-bscw.fit.fraunhofer.de/pub/bscw.cgi/39770946

relationship between students' SRL competence and performance as well as which type of students in terms of SRL level the teachers prefer to teach.

According to the results of the TPSRL survey, the majority of the teachers that responded had an awareness of SRL and independent learning. Most of them also recognised the important function of SRL alongside its significance to them as well as to students. Some respondents related SRL to increased maturity and, therefore, an acceptance of responsibility for one's own learning. Several teachers regarded SRL as a joint venture, i.e. learning together with students and "discovery together". SRL was also seen to influence students' ability to learn faster. Various teachers recognised that SRL could improve their students' reasoning or questioning abilities as well as their concentration power and, therefore, their capacity to learn. Some alluded to a teacher's moral duty to guide/show "right" path using SRL techniques, thus adding to the all round development of students, i.e. implying that it was an implicit responsibility of all teachers.

The strategies the respondents to the survey use in order to motivate and support students in becoming self-regulated are quite varied. One of these strategies consists of providing specific academic study skills facilities outside the classroom, available as face-to-face as well as via online support from the university, i.e. blended approach. Additionally, several teachers direct students to online and/or library-based "learning to learn" resources. Some teachers prefer to offer less help to their students, thus encouraging them to take more initiatives and learn for themselves. "Leading by example" is also a popular strategy: the teacher indicates or offers different approaches to resolving subject-based problems but leaves the students to choose their own learning path. Finally, the majority of the respondents agreed that encouraging active learning through peer collaboration helps motivate SRL of their students. In particular, some teachers promote working together with their students, e.g. through semi-directed projects, or they encourage group work.

The survey was also quite revealing with regard to some of the challenges in motivating higher education students to become self-regulated learners. Several respondents stated that many students are simply not equipped to learn at an HE level. They also mentioned that their students are reluctant to accept new methods of learning or change in their outlook on learning. On the other hand, most students expect to be provided with precisely defined learning materials and strategies by their teachers. One of the themes that emerged was that inspiring groups of students that have mixed learning skills is challenging in itself. Students with fewer SRL skills require more time to assimilate information or discover new methods of learning. This has implications for the teacher in terms of effort required to meet the needs of the entire spectrum of learning skills in the classroom. Most importantly, the teacher may not have enough knowledge, experience, or personal confidence to include SRL in the delivered curriculum time frame.

Experiences in the Summer Schools

In the years 2010–2012 several workshops on SRL were organised, mainly for Ph. D. students in the TEL area at the JTEL Summer Schools. Three key target groups were considered at these events, namely learners, teachers, and developers. At the workshops the objective was to demonstrate the conceptual and technical solutions for personalised support of SRL. In the introductory part we aimed to explain how psycho-pedagogical theories impact the design of learning environments, considering principles of SRL. We emphasised the role of decision making for the quality of the learning outcome and that it should be supported properly to optimise learning for benefit of the learner. Specific support strategies for SRL were explained taking into account the various SRL concepts. The participants tried out the ROLE software aiming to create a PLE. Experience from these events has shown that Ph.D. students understood the ROLE approach quickly and managed to design their PLEs without bigger problems.

In the practical part they elaborated approaches for personal support in small groups. The approaches were made with paper-and-pencil or with respective tools on their laptops. Each group presented their results followed by a discussion with the other participants. The group work was active and creative. However, it also turned out that it was really difficult for the students to find good and innovative solutions. As a conclusion it can be reported that the concept of personalised support for SRL can be explained to Ph.D. students, but it is very difficult that they find new solutions in a 3-h workshop.

In 2010 we conducted a survey to test the impact of choice architecture on the responses of people and to find out what Ph.D. students think on some issues in TEL. Our respondents (advanced learners) mostly thought that too much freedom for the learner may be overwhelming and contra productive. Similarly, they agreed that learners needed pedagogical assistance. Finally, almost all of them appreciated availability of a competent tutor. In addition to these findings we could easily see how important it is to find good explanations of SRL concepts in order to achieve a common understanding. Slight changes in wording may dramatically change responses. At the same time this demonstrated that to identify real opinions and preferences of people may be a tricky issue and the concept of choice architecture can influence them essentially.

Conclusion

The ROLE project has aimed to achieve progress beyond the state of the art in user-centric responsive and open learning environments. A key objective of this intention was the development of a psycho-pedagogical framework. The most important goal of this framework is to support learners to learn in a self-regulated way in responsive open learning environments. Based on this framework, a variety of support strategies have been developed. This approach is grounded on a literature review on SRL and experiences made in the test beds and in workshops with students, teachers, and researchers.

One of the most important findings was that adopting the self-regulated way of learning can be very difficult especially for weak learners of learners not used to freedom in their learning process. In such situation technological support strategies alone are not sufficient and not successful. Therefore, a holistic support strategy is needed, which includes several factors: (1) Material (e.g. videos) that motivates learners and raises their attention for SRL. (2) Courses that provide step-to-step introduction to SRL, so that learners can practice and get use to a new form of learning. (3) Preconfigured environments that already support SRL, so that the learner does not have to start from scratch. (4) Peers should be included in the learning situation, which leads to communication and reflection on the own learning process. (5) Finally teachers (if available) should take care to support learners. It turned out that also teachers need introduction and awareness for SRL, because not all teachers do fully understand the concept of SRL.

Five key aspects have been identified as essential for the psycho-pedagogical approach: Personalisation, degree of guidance, motivation, meta-cognition, and collaboration. Each support strategy takes into account at least one of these aspects. The SRL process model describes the learning process and thus serves as a backbone for support strategies. Based on these aspects, several support strategies have been developed (see section "Support Strategies"). However, these strategies are just examples demonstrating how support for SRL can be provided. Actually there is still room for new and more sophisticated support strategies. Future research and development can (and should) be done in this field. Taking into account the theoretical approaches described in this chapter, future possibilities for supporting learners will emerge.

One of the limitations we faced during the project was the technology-based assessment of SRL competences. It turned out that automatically assessing SRL competences (e.g. by monitoring the learner when using the learning environment) is much more difficult than expected. Especially in this field there is room for further research. In order to overcome this problem, teachers were asked to estimate the SRL competences of their students and also students were asked to self-estimate their SRL competences. However, a method to automatically determine the SRL competences would still improve the learning process and would give new possibilities to support the development of SRL competences and to personalise the recommendations of learning resources and activities.

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A Multidimensional Evaluation Framework for Personal Learning Environments

Effie Lai-Chong Law and Fridolin Wild

Abstract Evaluating highly dynamic and heterogeneous Personal Learning Environments (PLEs) is extremely challenging. Components of PLEs are selected and configured by individual users based on their personal preferences, needs, and goals. Moreover, the systems usually evolve over time based on contextual opportunities and constraints. As such dynamic systems have no predefined configurations and user interfaces, traditional evaluation methods often fall short or are even inappropriate. Obviously, a host of factors influence the extent to which a PLE successfully supports a learner to achieve specific learning outcomes. We categorize such factors along four major dimensions: technological, organizational, psycho-pedagogical, and social. Each dimension is informed by relevant theoretical models (e.g., Information System Success Model, Community of Practice, self-regulated learning) and subsumes a set of metrics that can be assessed with a range of approaches. Among others, usability and user experience play an indispensable role in acceptance and diffusion of the innovative technologies exemplified by PLEs. Traditional quantitative and qualitative methods such as questionnaire and interview should be deployed alongside emergent ones such as learning analytics (e.g., context-aware metadata) and narrative-based methods. Crucial for maximal validity of the evaluation is the triangulation of empirical findings with multi-perspective (end-users, developers, and researchers), mixed-method (qualitative, quantitative) data sources. The framework utilizes a cyclic process to integrate findings across cases with a cross-case analysis in order to gain deeper insights into the intriguing questions of how and why PLEs work.

Keywords Evaluation • Multi-method • Usability • User experience • Community of practice • Self-regulated learning • Diffusion of innovation • Cross-case analysis • Automated monitoring

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Introduction

Among others, a critical success factor in technology-enhanced learning is the personalization of learning experience. As emphatically pointed out in the Leuven/Louvain-la-Neuve Communiqué of the Bologna Process 2020, "student-centered learning requires empowering individual learners, new approaches to teaching and learning, effective support and guidance structures and a curriculum focused more clearly on the learner" (p.3). Personalization is also a key issue for implementing mechanisms to foster and increase activities in informal and lifelong learning networks. This implies a need for new technology-enhanced learning models that start from the learners and satisfy their unique needs in order to achieve a personalized learning experience for everyone.

Recent discussions about technologies for learning have shifted from institution-managed learning management systems (LMS) to user-controlled social software for learning. Indeed, the advent of Web 2.0 technologies has phenomenally transformed the way in which users consume, communicate, collaborate, and create information and knowledge on the Web. These technologies have underpinned the emergent notion of *Personal Learning Environment* (PLE), which is characterized by qualities such as personalization, openness, responsiveness, flexibility, shareability, interactivity, and sociability. PLEs can be perceived as both a technology and a pedagogical approach (Attwell 2007; van Harmelen 2006; Johnson et al. 2011; Johnson and Liber 2008; Schaffert and Kalz 2009) that aim to empower students to be in charge of their own learning by selecting tools and resources to create, organize, and package learning content, thereby meeting their personal needs and goals (McLoughlin and Lee 2010).

Nonetheless, the high hope held for the PLE to be a key enabler for lifelong learning is yet to be shown because the research and practice on PLE is still evolving. Specifically, substantive claims about the power of PLE should be grounded in relevant case studies, which, however, are limited in number and scope (Johnson et al. 2011). The paucity of case studies and missing evidence on the success or usefulness of PLEs can be attributed to the lack of a comprehensive evaluation framework for PLEs. The difficulties of evaluating PLEs have been documented (e.g., Gillet et al. 2011; Giovannella 2011). While technical implementations have demonstrated some significant progress (see Chaps. 5 and 8 in this volume), the empirical evaluation of PLEs lacks behind. Indeed, the development of an evaluation framework for PLEs poses several major challenges:

- PLEs are not a stable technology that can be prepared and used in a controlled environment. In fact, PLEs do change over time and can be highly dynamic.
- PLEs integrate other technological artifacts that are designed independently from each other and can stem from different providers. This leads to possible (unintended) interdependencies, usability issues, and update state problems.
- PLEs are used to combine formal and non-formal learning contexts. Therefore the purpose of using a PLE can be highly heterogeneous, rendering systematic comparisons across different learners very difficult.

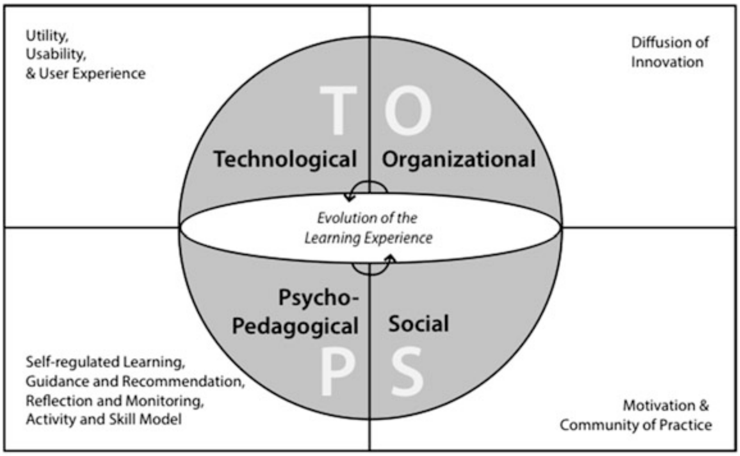

Fig. 1 Four perspectives (the TOPS model) for PLE evaluation

To tackle these challenges, mixed-method and multi-perspective evaluation approaches are deemed relevant to address the complexity of PLE usage and its effects on learning behaviors and learning outcomes.

Four main perspectives can be identified: *technological*, *organizational*, *psycho-pedagogical*, and *social* (short: "TOPS"), with each being informed by specific concepts and theories and subsuming certain methods and tools (see Fig. 1). They are elaborated in the following with reference to related work of the ROLE project (http://www.role-project.eu/).

The "TOPS" Model for Evaluating PLEs

In this section we delineate the individual perspectives of the TOPS model—with specific emphasis on their respective underlying conceptual and theoretical frameworks.

Technological Perspective

The technological perspective comprises two main aspects: *utility* and *usability* and *user experience*. It is to emphasize that the user-centered design (UCD) approaches underpin the work of PLEs, so not only end-users' but also developers' perspectives should be taken into account.

Utility

Two major elements of utility to be evaluated are *software* and *documentation*, which are discussed in detail in the following.

Software evaluation pertains to the functionality of different software components constituting PLEs, including widgets, widget containers, the widget store, libraries, services, tools, and the overall interoperability framework. It is essential to evaluate how useful these components are to enable end-users to accomplish specific tasks and goals.

As already indicated above, the strict separation of end-users from developers can be seen as artificial (at least under the UCD approach), thus requiring an evaluation approach to look also at developers and "power" users who engage in customization, configuration, or even end-user-driven development (keyword: mash-ups). Typically, such developers and power users use configuration options, authoring tools, and APIs allowing for the mash-up of components to customize or even create new software artifacts.

Specifically, we highlight a list of factors critical for the technical evaluation of software, which are adopted from constructs of the Information System Success Model (ISSM) (DeLone and McLean 2003) and the Technology Acceptance Model (TAM) (Davis 1989; Venkatesh et al. 2003; Venkatesh and Bala 2008) (see Table 1).

Table 1 Constructs relevant to the utility evaluation of PLEs

Construct	Factor
System quality	Integration
	Portability
	Availability
	Performance
	Reliability
	Usefulness of features
	Completeness of features
	Security
Information quality	Usefulness of information
	Completeness
	Correctness
	Appropriateness of presentation format
Service quality	Responsiveness
	Support
	Feedback mechanism
	Trustworthiness
Use	Users, communities
	Functionality accessed
	Information items accessed
	Duration of use
	Frequency of use

An increasingly popular data collection method is *automated monitoring*: monitoring and data logging for capturing how frequently a service or a feature has been used and how often different significant events have occurred (Helms et al. 2000). More specifically, raw data of system use are recorded and then aggregated for computing measures for individual factors. For example, "mean time to failure" is a measure for the factor "reliability" under the construct of "system quality" that can be derived from monitoring data, including information about what and when errors occur.

Contextual information gathering (i.e., information about the current situation where a learner deploys specific software) is also important. Noteworthy is that context has a technical and social aspect: which software/browser is used for accessing a PLE, which types of data are accessed, and which people interact with each other in a certain community. In principle, physical context information can also be recorded if the sensor data required would be available (e.g., GPS coordinates for spatial location). An example of including contextual data in evaluation is a factor "Browser Compatibility," where the number of errors occurred related to a particular browser can be measured. Similarly, a factor "Widget Container Interoperability" can be measured by associating errors with a particular widget container where they occur.

Where it is possible and does not infringe privacy and security regulations, it may often be safer to capture a broad standard range of monitoring data, especially as capturing technologies typically require no further human effort beyond initial setup and the setup is often already integrated into the related software. Subsequently, such data can be selected, refined, and processed based on the actual needs and goals of an evaluation project.

Croll and Power (2009) provide an elaborate list of metrics that can be used for monitoring usage of web-based technologies. Some of the key metrics relevant to PLEs are: user-generated content, content popularity, loyalty, search effectiveness, reflection, enrolment, conversion, and abandonment.

There are a number of ways for collecting data for these metrics. *Google Analytics* are a free service to generate a comprehensive range of usage statistics for any web-based application. Following the insertion of a small JavaScript code snippet into a given web application, Google starts to record usage statistics (including simple demographic features and events). Some of the key aspects that Google can currently track are

- *Visitor Tracking*: Demographics, conversion, uniqueness, loyalty, etc.
- *User Profile*: browser, OS, screen resolution, Java availability, flash availability, connection speed, etc.
- *Events*: frequency of use of specific event categories, events per visit, total number of events.

One of the drawbacks of using analytics is the limited capability to provide data describing how users interact with content and tools (known as attention metadata) within their environments. Collecting *contextualized attention metadata* (CAM) will enable us to infer the ways learners use technologies and tools for specific purposes. The CAM approach proposed by Wolpers et al. (2007) supports such tracking of attention metadata. This approach helps observe the user at the application level, enabling association of tool usage with content-specific behavior *in context*. The challenge of collecting observation data of user attention unobtrusively can be resolved by the CAM approach through integrating the data-capturing process into a user's daily working environment. This approach allows integrating data from web applications (e.g., by mapping the Apache open log file format to CAM) as well as from desktop applications. CAM helps track learning content usage, analyze behavioral patterns, provide similarity measures between users, and allow inferences about user goals. CAM data can be utilized to measure the effectiveness of PLE technologies in providing the learner with a highly responsive and personalized learning environment. CAM data can also be used to track and infer self-regulatory activities for measuring the effectiveness of the psycho-pedagogical model (Scheffel et al. 2010a, b).

All measures that cannot be derived with automatic monitoring need to be obtained from users explicitly. The challenge is to identify appropriate techniques for survey data acquisition with the possible lowest obtrusiveness and highest intuitiveness for users.

For instance, a lightweight "Requirements Bazaar" approach is integrated into the ROLE Widget Store (http://role-widgetstore.eu/) similar to other well-accepted systems such as Google's Android Market or the Chrome Extensions marketplace. This is a valuable source of data since their users provide feedback on the quality of tools, services, and widgets using means such as rating scales, and—where appropriate—free text comment boxes.

Documentation evaluation looks into the availability and quality of technical documentation—a prerequisite for software to be accepted by end-users as well as developers. To encourage developers to contribute new learning technologies by mashing up existing software components, it is necessary to ensure that documentation is correct, complete, and tailored to developers' needs.

With regard to the development of web-based software components, developer documentation of the infrastructure usually includes the following items:

– The set of initial documents (e.g., an overview of the underlying principles and overarching architecture).
– The reference documentation with complete information on all supported features, usually in the form of API documentation.
– The set of tutorials demonstrating how to use the technology for developments on simple and useful examples.

Specifically, technical documentation should be tested by inviting developers to practical sessions, where they are asked to use the infrastructure and accompanying documentation to realize a small but motivating use case beyond basic tutorial contents. In such sessions, the developers who authored the documentation can serve as tutors to be consulted to discuss any problems arising. Such discussions can be used as individual interviews or focus groups to collect feedback on the quality of the software as well as documentation. This approach, however, does not scale to large groups of developers. This is where the required alternative means such as online tools are preferred over presence workshops.

Documentation of web-based software is usually supplemented by different technical means for communicating with the core developers of the original technology, authors of the documentation (who often are also its developers), and developers deploying these software artifacts. For instance, developers use online forums to get in contact with other developers to report problems and ask for help. Besides bug reports, such comments often contain practical questions about how to accomplish certain tasks, thus indicating where the existing documentation could be unclear or incomplete.

Further means to assess the utility of documentation is to directly integrate ratings, for instance, in the form of 5-star scales, like/dislike buttons or commenting functions, into the online documentation. In this manner, different factors from the dimension Information Quality can be surveyed. These (and additional) features are often already provided by software project management systems such as SourceForge, GitHub, and the like.

Usability and User Experience

First of all, it is deemed imperative to demarcate usability from user experience (UX)—two key concepts in the field of human–computer interaction (HCI). One main distinction is that usability targets *instrumental quality*, emphasizing the effectiveness and efficiency of task and goal attainment with interactive technologies, whereas user experience targets *non-instrumental quality* (e.g., aesthetics), going beyond the traditional task-oriented focuses to address users' affective and emotional responses (e.g., fun, pleasure, surprise, sad, happy) to interactive technologies (e.g., Hassenzahl 2013). Hassenzahl's (2005) oft-cited model on the pragmatic and hedonic quality illustrates similar arguments. Despite its decade-long history, some basic conceptual issues in UX are yet to be resolved (Law et al. 2009; Law, van Schaik & Roto, 2014). While a deeper exploration of such issues is beyond the scope of this chapter, here we highlight metrics and approaches relevant to the evaluation of PLEs.

Noteworthy is that usability and user experience evaluations focus on the interaction design of technological components underpinning PLEs, which nonetheless contribute to the holistic educative experience with PLEs (see also section "Psycho-pedagogical Aspect").

Usability

The usability of different technological components of PLEs (section "Utility") is to be evaluated based on a combination of metrics identified from the literature (e.g., Nielsen 1994) and standards (ISO/IEC 25010:2011[1]; ISO/IEC 9241-110[2]: 2006 and ISO/IEC 9241-210: 2010[3]). The metrics are listed as follows:

– *Learnability*: The ability of the technology to enable users to learn with great ease how to assemble a PLE themselves. If users find it difficult to assemble a PLE, then the acceptance and uptake may be drastically hindered. Hence, the assembly process for such an open learning environment should be relatively straightforward for end-users. Some factors that enable us to ascertain learnability are consistency of user interface design and predictable system behavior. Learnability of PLEs is equally important for developers as for end-users. If developers find it difficult to use PLE software, they may not be able to create new widgets.
– *Efficiency*: The ability of the technology to support users to be highly productive. Features such as consistent look and feel, consistent navigation, frequent feedback, and availability of templates to help them quickly assemble their environments can contribute to the overall efficiency of the PLE software.
– *Memorabilit*y: The ability of the technology not to require users to reinvest time in remembering how to use it after a period of nonuse. Closely related with learnability, memorability can influence the uptake and usage of PLE. The key success factor for PLE is to make the assembly process of the environment highly intuitive, using relevant standardized visual cues.
– *Error Tolerance*: The ability of the technology to avoid catastrophic errors by making users reconfirm critical actions (e.g., deleting a software component) and to recover from errors by providing the "un-do" feature that allows users to reverse their actions.
– *Effectiveness*: The ability of the technology to help users achieve their goals. Using PLEs, if learners are able to assemble and personalize their environments with ease, while at the same time they find the recommendations and rated/ranked content useful for fulfilling their goal, then we can infer that the technology is effective and that learners are likely to feel satisfied. More explicit methods are mentioned above in section "Utility."
– *Flexibility*: The ability of the technology to offer a range of services so as to be able to adapt to task changes. The ability of learners to seamlessly integrate and use a range of web-based tools and services for assembling their learning environments and for exporting/importing data as well as settings to other similar technologies.
– *Operability*: The ability of the platform to allow users to operate and control it.
– *Satisfaction*: The ability of the platform to be deployed by users without discomfort. It is highly subjective as compared with the other qualities listed above, which when realized to a sufficiently large extent, can contribute to overall user

[1] Systems and software engineering: Systems and software Quality Requirements and Evaluation.

[2] Ergonomics of human-system interaction: Part 110: Dialogue principles.

[3] Ergonomics of human-system interaction: Part 210: Human-centered design for interactive systems.

satisfaction. Note that in addition to the system and service qualities, information quality can play a key part in user satisfaction, according to the ISSM (DeLone and McLean 2003).

Usability evaluation methods comprise a range of *usability inspection methods*, *user-based tests*, and *user surveys*, which can be used to evaluate PLEs using the metrics described above. Inspection methods rely on experts, whereas user-based tests and user surveys, as the names suggest, involve end-users (an overview, see Holzinger 2005).

Two commonly used inspection methods are *heuristic evaluation* and *cognitive walkthrough*. For heuristic evaluations, experts examine a system based on ten usability heuristics or principles that were originally derived from a large database of common problems. Violating any of such principles is identified as usability problem of which the severity is estimated so as to inform the urgency and necessity of its being fixed (Nielsen 1994). The major advantages of this method are that it can be applied throughout the whole development lifecycle and is, relatively, less time-consuming. In a cognitive walkthrough, experts analyze a system's functionality with a set of four questions (e.g., "Will the user notice that the correct action is available?") to estimate how the user would interact with the system (Lewis and Wharton 1997). A negative response to any of the questions suggests the identification of a usability problem.

All inspection methods, as prediction methods, are prone to false alarms and results thereof are typically to be verified with user-based tests, such as *think aloud* or *field design methods* and *observation methods* (e.g., video observation, screen sharing, mouse tracking, eye tracking). Usability evaluation feedback is deployed for further development of the system under scrutiny, as they can provide insights into where and why usability requirements are not met.

Think aloud is a method that requires end-users to constantly think aloud as they are using a system individually or collaboratively in order to understand how they perceive the features of the user interface, identify preferences, and discover any potential misconceptions at early design stages (Dumas and Fox 2007). The drawback of this method is that it can be tiring for end-users who have to focus and behave in a rather unnatural manner by giving a running commentary on their own actions.

Field methods are a collection of tools and techniques for conducting user studies in context. Among others, Contextual Inquiry (Beyer and Holtzblatt 1998) is commonly used field method in research as well as in practice. The main advantage of such methods is that they provide a development team with data about what and how (and why) people carry out their tasks in a given environment, thereby enabling the production of useful and usable systems that meet people's needs and goals. The main disadvantage is that they are time-consuming. Nonetheless, such methods can be streamlined with respect to the budget available for evaluation in a project (Wixon et al. 2002).

Furthermore, while the importance of automated monitoring techniques was already highlighted above, methods such as CAM and Google Analytics may not provide sufficient granularity of data to determine the usability of the PLE software. The ability of CAM to provide granular and contextual data may be useful, but its appropriateness may not be established unless or until a sufficient amount of data has been collected. Apart from traditional methods mentioned above, there are two additional methods that can be useful for small-scale (eye tracking) and large-scale (mouse tracking) usability evaluations:

– *Eye tracking* measures visual attention as people navigate through websites. It is useful in quantifying which sections of an interface are read, glanced at, or skipped/ignored. Eye tracking is generally carried out in laboratories and at a small scale. It can provide useful information for evaluating the effectiveness of the learning design (Schwonke et al. 2009; van Gog and Scheiter 2010) and it can be used to gather data after every redesign phase before large-scale rollout.
– *Mouse tracking* is a technique for monitoring and visualizing mouse movements on any web interface. Mouse movements provide key data about usability issues on a large scale, as users can be observed in their natural habitat in an unobtrusive and continuous manner. In most cases, a JavaScript code snippet is inserted to track mouse movements. Privacy issues must be considered while adopting this method. Tools like Crazyegg,[4] Userfly,[5] and Simple Mouse Tracking[6] can be used for this purpose. It should be mentioned that even more so than eye tracking, data captured with this method represent only part of the story and, hence, must be triangulated with other qualitative data to ensure completeness and correct interpretation.

For summative usability evaluation, *user surveys* are deployed. They are normally administered in the final phase of a project after end-users interact with an executable prototype. Among others, the System Usability Scale (SUS) is widely used in research and practice, as it is simple with only ten items and standardized with psychometric properties (Brooke 1996).

To study the usage of PLEs, it is crucial to evaluate whether the associated services and features can help achieve learning objectives. This can be derived from *evaluation metadata* such as ratings, bookmarks, tags, and comments provided by users (Vuorikari and Berendt 2009): One important aspect here is to investigate how the PLE usage facilitates social interactions, triggers discussions, and improves the understanding of learning content (Mason and Rennie 2007; Farrell et al. 2007; Rollett et al. 2007). Moreover, when it comes to learning material recommended by the system, ratings and like/dislike evaluation metadata can help assess unobtrusively to what extent learners deem them useful.

[4] http://www.crazyegg.com/

[5] http://userfly.com/

[6] http://smt.speedzinemedia.com/smt/

User Experience

The literature on UX published since the turn of the millennium indicates that there are two disparate stances on how UX should be studied (i.e., qualitative versus quantitative) and that they are not necessarily compatible or can even be antagonistic. A major argument between the two positions is the legitimacy of breaking down experiential qualities into components, rendering them to be measurable. A rather comprehensive review on the recent UX publications (Bargas-Avila and Hornbæk 2011) identifies the following observations: UX research studies have hitherto relied primarily on qualitative methods; among others, emotions, enjoyment, and aesthetics are the most frequently measured dimensions; the products and use contexts studied are shifted from work to leisure and from controlled tasks to consumer products and art; the progress on UX measures has thus been slow.

Given that UX has at least to some extent developed from usability, it is not surprising that UX methods and measures are largely drawn from usability (Tullis and Albert 2008). However, the notion of UX is much more complex, given a mesh of psychological, social, and physiological concepts it can be associated with. Among others, a major concept is emotion or felt experience (McCarthy and Wright 2004). As emotion arises from our conscious cognitive interpretations of perceptual-sensory responses, UX can thus be seen as a cognitive process that can be modeled and measured (Hartmann et al. 2008).

Larsen and Fredrickson (1999) discussed measurement issues in emotion research with reference to the influential work of Ekman, Russell, Scherer, and other scholars in this area. More recent work along this direction has been conducted (cited in Bargas-Avila et al. 2011). These publications point to a common observation that measuring emotion is plausible, useful, and necessary. However, like most, if not all, psychological measurements, they are only approximations (Hand 2004) and should be considered critically. Employing quantitative measures to the exclusion of qualitative accounts of user experiences, or vice versa, is too restrictive and may even lead to wrong implications (Law et al. 2014).

There exist a range of UX evaluation methods (e.g., Vermeeren et al. 2010). For qualitative data, narrative or storytelling methods (e.g., Riessman 2008) are commonly employed. For instance, users' short descriptions about their positive and negative interaction experiences can be analyzed with the use of machine learning as well as manual coding approach (e.g., Tuch et al. 2013). For quantitative data, validated scales with good psychometric properties such as AttrakDiff2 (Hassenzahl and Monk 2010) and PANAS (Positive Affect and Negative Affect Scale; Watson et al. 1988) are increasingly used.

Especially challenging is to operationalize a diversity of emotions, be they positive and negative, because teasing out their nuances proves difficult. Common methods here are self-assessment manikins and Emocards (for a summary, see Stickel et al. 2011). It is even more demanding to measure the social aspect of UX, which has hitherto been defined as highly individual and contextualized (Law et al. 2009).

Organizational Aspect

With their capability for personalization and plasticity, PLEs help create a rich and diverse learning technology ecosystem promising perpetual change and innovation. The uptake and effects of PLEs at an organizational level can be understood in the light of theory of Diffusion of Innovation, which is advanced by Rogers (1995): "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p.11).

Furthermore, Rogers (1995) states that the "innovation diffusion process" progresses over time through five stages: *knowledge* (when adopters learn about the innovation), *persuasion* (when they are persuaded of the value of the innovation), *decision* (when they decide to adopt it), *implementation* (when the innovation is put into operation), and *confirmation* (when the decision is reaffirmed or rejected).

The ROLE project conducted a study to identify factors that can have an effect on the adoption and diffusion of PLE-related technologies in organizations (Chatterjee et al. 2013). Table 2 presents an overview of the factors identified.

Among the main organizational factors, the outlook of the top management on introducing technological change matters, as this particularly influences persuasion strategies for facilitating positive decision-making in terms of PLE adoption. It is equally important to look at how coherent or unified the views on PLEs of the key stakeholders within the organization are. With the increasing popularity of social media within commercial organizations, extensive use of such platforms can have positive impacts on informing the stakeholders about key concepts and issues around PLEs.

The top management, as per the findings of the study, is particularly interested in the cost-effectiveness PLEs offer as compared to existing solutions in place—the perceived cost-effectiveness thus plays a key role here for evaluation. Compatibility with the existing technical infrastructure and high learnability are other key success factors of introducing innovation. These persuasive factors tend to act in a push–pull mechanism (Shih 2006) before embarking on the decision-making stage.

Table 2 Potential factors influencing organizational uptake

Categories	Factors
Organizational	Leaderships attitude towards change
	Strategic alignment
	Learning culture
	IT support
Innovation (PLE)	Perceived cost-effectiveness
	Compatibility with existing system
	Perceived effort expectancy
External factors	Perceived factuality
Communication channels and influence	Line manager
	Social networks

Once the key stakeholders within an organization are informed and persuaded about the usefulness and utility of PLEs within their organization, the top management may then take the two key factors into account when deciding upon the adoption of the new learning technologies.

PLEs enable the learners to take control of their own learning depending on their contextual needs and goals. It is therefore crucial to check whether a framework exists that allows relating personal goals directly to organizational goals. Similarly, the learning culture should not be dominated by didactic and trainer-facilitated approaches, as a healthy sign of PLE adoption is that learners take control of their own learning and managing the related technologies. It is necessary to look at the provision of IT support (particularly in the introduction phase), when stakeholders start using PLEs within their day-to-day activities. Another important factor that determines the PLE adoption is its use by line managers. If line managers and senior team do not lead by example, then the likelihood of PLE adoption can be adversely affected.

Psycho-pedagogical Aspect

From the psychological and pedagogical perspective, the key aspects to look at are the ability to foster self-regulated learning, the guidance and recommendation strategy, and the facilities for reflection and monitoring. Moreover, the availability and documentation of an activity and skill model play an important role—and how far this is put into practice.

Self-regulated Learning

From the psycho-pedagogical perspective, effective exploitation of PLEs, which support lifelong learning, hinges crucially upon the learner's self-regulated learning competence. The quality of learning outcomes varies with the extent to which learners are capable of regulating their own learning (Steffens 2006). Self-regulated learning approaches have been evolving since the 1970s in educational research and practice (Efklides 2009).

Successful deployment of PLEs relies on a self-regulated learning process model such as the following one (derived from Zimmerman 2002), where it is seen as a learner-centric cyclic model consisting of four recurring learning phases: learner profile information is defined or revised; learner finds and selects learning resources; learner works on selected learning resources; and learner reflects and reacts on strategies, achievements, and usefulness.

Note that while cognitive learning activities are rather related to actual learning (i.e., information receiving, debating, and experimenting), meta-cognitive learning activities are related to controlling and reflecting on one's own learning.

With respect to the evaluation of the success and extent of self-regulated learning, gathering data about the accuracy and usefulness of the learning process model is crucial. It is particularly relevant to find out, whether learners can actually follow the process model and whether they comprehend it and its implications. Another key question is, whether the process model supports the development of self-regulatory skills.

It should be taken into account that the process model can be applied in different contexts and situations. For example, learners might be in a collaborative learning situation, where they may learn together with peers. Or they may learn on their own. In addition, the actual learning technology mix may make a difference, since learners might use tools and widgets explicitly built to support self-regulated learning, whereas in other cases, performance of meta-cognitive learning activities may happen just in an implicit way (i.e., being aware of them).

One particularly useful instrument to help in the evaluation of self-directed learning is the questionnaire. While it certainly is supportive of all other aspects mentioned above and following below, this widely used instrument can help here in providing structured, often numerical data. Questionnaires can be administered without the presence of the researcher, and are often comparatively straightforward to analyze (Wilson and McLean 1994). According to Cohen et al (2000), "Though there is a large range of questionnaires that one can use, but there is a simple rule of thumb to follow: the larger the size of the sample, the more structured, closed and numerical the questionnaire may have to be, and the smaller the size of the sample, the less structured, more open and word based the questionnaire may be" (p. 247). Questionnaires are particularly useful when comparison across groups is required (Oppenheim 1992).

Guidance and Recommendation Strategies

Guidance for learning in the context of PLEs depends on the situation and on who is providing the guidance. Learners can learn in a blended learning situation with teachers structuring the learning process. Peers can be involved in the learning process, if learners collaborate in some way. Learners can also learn on their own without human interaction. In the first case, teachers can provide guidance. In the second case, peers can provide guidance either directly or indirectly (e.g., with peers attempting to master a problem together). In all cases, guidance can also be provided by the system through personalized recommendations.

Moreover, the scope of guidance can focus on a variety of things, including the search for learning resources (e.g., widgets, content, or peers), the composition of a PLE, the control over the learning process, and the improvement of self-regulation ability. Evaluating the effectiveness and appropriateness of such guidance strategies requires looking into its preconditions: the given abilities of learners are relevant, since it depends largely on concrete skills of learners, what they can do on their own and where they need help.

Furthermore, goals and preferences need to be investigated because the scope of guidance depends on these factors. It should be noted that it depends on who is delivering guidance, whether certain preconditions can be taken into account, and to which extent. If the system provides guidance, then this is done usually in terms of recommendations. Personalized recommendations are based on a learner model (e.g., goals, skills, learning history, learning progress, background of a learner, and the learner's preferred instructional technique), which models the preconditions for guidance.

The scope of recommendations can include concrete widgets, content resources, peers, learning activities, and complete learning environments (i.e., sets of learning resources). By recommending certain meta-cognitive learning activities, guidance for self-regulated learning can be provided. In case of teacher guidance, learning environments can be pre-configured. Especially in a blended learning situation, teachers can support the use of the learning environment and help improve self-regulated learning, providing further scaffolds to system guidance.

Regarding evaluation, it is important to assess the appropriateness and quality of guidance strategies. This includes evaluating, whether the respective guidance strategy helps learning effectively and whether the guidance provided helps overcome difficulties. Different guidance strategies have different purposes: it requires an evaluation of whether all purposes are actually achieved.

While of course the questionnaire (see above) can be utilized to evaluate the success of particular guidance and recommendation facilities in their context, other qualitative methods are suitable as well—such as focus groups, the nominal group technique, and a Delphi study. Quasi-experiments using test collections and statistical measurements are the dominant quantitative methods.

A focus group is a small group of people who get together to discuss a certain issue given to them normally by a researcher. It usually consists of 6–10 members and meets regularly during the lifetime of a project or in an ad hoc manner when a need arises (Vaughan et al 1996). The technique relies on interactions among group members. Focus groups are used to capture qualitative feedback to triangulate findings from some other data sources.

Two other techniques, namely Nominal Group technique and Delphi technique may be used to collect group opinion. The Nominal Group Technique was developed by Delbecq and Van de Van (1971, 1975) in the 1970s. It has been found to be useful in improving educational programs (Jones and Hunter 1995). There is further evidence in the literature that it was successfully used for evaluation purposes in higher education (Nisbet and Watt 1984). Grant et al. (2003) used the technique to determine the impact of student journals in postgraduate education.

The Delphi technique (Turoff 1970) is, like the Nominal Group technique, a structured process, but it does not require physical proximity among participants. The participants may be geographically dispersed and are not required to meet face to face. Either technique may be instantiated after validation trials to gather group data, augmenting and triangulating the monitoring or survey data.

Following the tradition of search engine evaluation, the relevance of recommendations can be evaluated in the so-called quasi-experiment with the help of a specially prepared test collection. In such a case, the learning resources (e.g., content, peers) are evaluated by experts or representative users; this allows comparing how well the recommender system performs in bringing up the most relevant and most complete recommendation. Evaluation measures depend on the guidance strategy: for example, recommendations fostering serendipity have much more relaxed requirements on accuracy as compared to identifying potential peers who are currently in a similar learning situation. An overview on possible evaluation measures (and their application contexts) can be found in Herlocker et al. (2004).

Reflection and Monitoring

Learner information is important for guidance strategies; this can be the assessment of a teacher, peers, or the learner herself. A teacher and peers might form an opinion by observing, the learner can do this by self-monitoring or self-reflection, and the system can do that by tracking the learner's behavior and building a learner profile (or recommending profile information). Most importantly, a mixed procedure can be used if profile information is proposed by the system and the learner has to modify and update it. In this case the learner is made aware of certain assessment outcomes, which also stimulates self-reflection. As already mentioned above, learner profile may contain information about goals, skills, learning progress, etc. Evaluation should focus on the accuracy of this information.

While an interview can be used for the evaluation of many of the other aspects listed above and below, it is particularly useful for the evaluation of reflection and monitoring. An interview is a purposeful discussion between two or more people (Kahn and Cannel 1957). One of the most distinct advantages of interview over, for instance, questionnaires is that the researcher has personal contact with the respondent and hence more control over the questions and its context. The researcher is available to clarify confusing questions (Cohen et al 2000), which is difficult to do with questionnaires. This same advantage, however, can also turn into a disadvantage, when the researcher knowingly or unknowingly diverts the discussion and when allowing personal bias to directly impact on outcomes. Interviews consist of a more direct method that helps easily spot user preferences, satisfaction, and encountered problems.

Apart from qualitative approaches, quantitative evaluation techniques utilizing content analysis over learners' writings are emerging, some of which using automation techniques from text mining and statistical processing. Ullmann et al. (2013) provide an overview and a framework for the study of reflection by hand and with the help of automation techniques; from natural language processing as well as using crowd-sourcing of human coding on platforms such as CrowdFlower or Amazon's Mechanical Turk.

Activity and Skill Model

For successful deployment of PLEs, the underlying skill model is typically complex, since in addition to the developed domain knowledge, self-regulated learning and the handling of PLE services and tools have to be considered. Any PLE skill model encompasses at least these three different kinds of skills: domain, tool, and self-regulation skills:

- Domain skills are skills that a learner possesses, if he or she has a certain level of expertise in a knowledge domain. For instance, the learner can explain what percentages she estimates to have attained and, if she prefers, justifies with some qualitative comments.
- Tool skills are defined as skills which a learner possesses, if she is able to perform a learning activity with a learning tool in a domain context: for example, the learner can use a tool for setting goals or can use a tool in order to retrieve domain knowledge in a certain topic. Different learning activities with the same tool can require different skills.
- Self-regulated learning skills imply the ability of a learner to regulate her learning activities by herself: the learner can realistically set own goals, monitor own progress, apply effective time management, and self-evaluate. Self-regulated learning skills are skills on a meta-level and domain independent.

For the evaluation, focus should be set on documenting and subsequently assessing accuracy and usefulness of these skill models. Methods for the assessment of accuracy and usefulness are essentially the same as those valid for evaluating the utility of PLE utility (particularly automated monitoring and CAM).

Social Aspect

A Community of Practice approach is an effective way of sharing knowledge. They are usually characterized by anonymity and an addictive, but voluntary behavior, with a strong sense of belonging (Hampton and Wellman 2001). Trust, loyalty, and social usefulness are pertinent motivational features identified in the virtual community context.

Over the last century, a number of motivational theories were proposed (e.g., Maslow 1954; Herzberg 1987; Vroom 1964). At the foundation of these theories, it is claimed, lies the suggestion that each school of thought focuses on certain factors to the exclusion of all others—for example, reward, social needs, or psychological growth.

A few key inferences in the context of PLEs from the motivational models are mentioned below:

- Recognition of a range of individual needs: Learners have varying levels of motivation depending on their needs.

– Goal alignment in the provision of materials: If a given task does not align with the learner's goal, then the motivation to complete the task will obviously decrease.
– Varying incentives: Incentives can help instill a sense of achievement and motivation to keep going. Learners will require varying levels of incentives of different natures to keep themselves motivated (grades, peer recognition, altruism, to mention just a few).
– Connectedness to community performance: Link of these incentives to performance at an organizational or community level.

To assess the social aspect of PLEs, Kim's (2000) application of Maslow's Hierarchy of Needs to online communities can be further adapted: Table 3

Table 3 Community building and motivation (extended from Kim 2000)

Need	Offline (Maslow)	Online communities (Kim 2000)	Personal Learning Environment
Physiological	Food	System access	Access to PLE technology, widget store, user profile
	Clothing	Ability to maintain own identity while participating in the community	Use of templates for assembly of environment
	Shelter		
	health		
Security and safety	Protection from crimes and war	Protection from hacking and personal attacks	Data security (automated monitoring data) and encryption
	Sense of living in a fair society	level playing field	multi-level privacy framework
		maintain varying level of privacy	
Social	Give and receive love	Belonging to the community as whole and within subgroups	Share and consume tools, content, and resources
	Feeling of belongingness		Belongingness
			Ability to collaborate across several social networks
Self-esteem	Self-respect	Contribute to community and get recognized	Sharing modified PLE templates
	Ability to earn respect from others		Altruism
			Mentoring
			Giving and receiving feedback
			Rating and ranking
Self-actualization	Develop skills and fulfill one's potential	Take on community role that develops new skills and opens new opportunities	Acquiring expert status within the community
			Assembly and regulation of own learning

illustrates which constructs are relevant to the PLE evaluation from a motivational perspective.

Clustering techniques and social network analysis (SNA) can be used to trace whether the infrastructure supports the emergence and evolution of self-directed communities of interest and practice (Wenger 1998). Both rely on either implicit factors (looking at interaction and usage patterns) or explicit ones (utilizing evaluation metadata).

SNA originates from sociology and network analysis that is widely applied in physics, electrical science, civil engineering, and others. In SNA, entities and relations among them are mathematically modeled as graphs, (i.e., sets of nodes and edges connecting them). Nodes and edges can have different semantics: for instance, nodes can be people and edges between nodes can be based on communication between people, for example, through e-mails or chats. Edges can also be used to denote citations of resources that peers own or create. For instance, a peer is connected with the other one whose work he has cited. According to the Actor Network Theory (Latour 1991), we can consider every node as an arbitrary actor, which is not necessarily human. In this sense, it is also possible to analyze networks consisting of users and tools, both modeled as nodes.

SNA is a basis for assessing social learning and the interaction with tools used in learning (Klamma 2010). It helps discover information about social relationships. Based on this, it allows inspecting social presence of learners within their communities: for example, it helps in evaluating which roles learners adopt or how their positions evolve over time, positively as well as negatively.

Since 1967 with the discovery of the small world network phenomenon (Milgram 1967), the heterogeneity of networks has been examined intensively. Newman (2003) showed that in scale-free networks, connections between nodes are distributed unequally with a certain probability. While most of the nodes have few connections, there exist a few nodes exhibiting a large number of connections. The connectivity of a graph representing a network informs about robustness and cohesiveness of the network (Brandes and Erlebach 2005). Freeman (1979) also pays attention to centrality measures that help us to reveal special roles of network nodes. Moreover, brokerage phenomena can hardly be defined without the application of SNA (Barabási 2007). Considering the irregularity of peer connections of networks, Newman and Girvan (2004) developed one of the clustering algorithms, which find groups of network nodes that are densely connected to each other but sparsely connected with other nodes.

Networks typically consist of several groups of learners communicating with each other and with other groups. SNA techniques and clustering allow unveiling the structure underlying such a network. For example, networks can include groups of learners that have connections only to leaders of groups, but don't have communications with other groups.

SNA techniques allow following behaviors of learners within a time frame by examining network centrality measures, which reveal expertise or presence of a learner within a network. This method of evaluation may show us how learners evolve in their communities over time: do they become experts or brokers of information from one to the other community or do they lose their position and lock themselves in a community closed from communication?

In practice, SNA requires the availability of data containing information on the nodes, i.e., people, groups of people or even tools, and on the edges, i.e., relations between nodes. One possible source of input for SNA can be the raw monitoring data. Here, different kinds of interaction between users are captured.

The Unified PLE Evaluation Framework

Based on the TOPS model and the background literature reviewed above, we propose an integrated evaluation framework for PLEs. Specifically, the framework incorporates major dimensions with a gradual progression from the individual to community focus. Figure 2 lists the key dimensions (and its aspects) of this evaluation framework and shows how they relate to each other: the framework is organized in three circles from the inner Technological one, which lays the cornerstone of PLEs, through the middle Psycho-pedagogical circle, which addresses individual user's needs and goals, to the outer Organizational and Social circle, which brings in the social and organizational factors relevant to the exploitation of PLEs.

The constructs highlighted within the three circles are high-level concepts, which should be translated into low-level variables, selected from the review brought forward in the previous sections. Operationalizing and estimating such variables with particular techniques and tools leads to results, which can somehow and somewhat account for the extent to which PLEs successfully enable users to attain their learning goals. For instance, the construct *usability* is translated into two

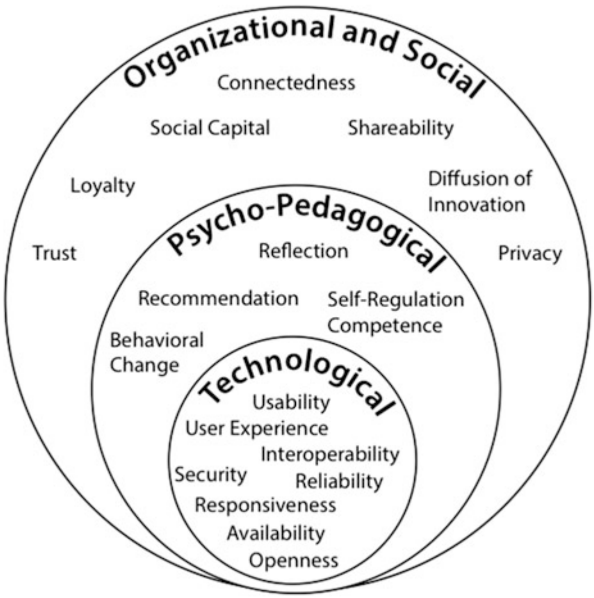

Fig. 2 The "TOPS" integrated evaluation framework for PLEs

metrics—*effectiveness* and *efficiency*— which can be measured in terms of number and type of errors and in the time to complete a specific task with a PLE.

Nonetheless, not every construct can be operationalized in a straightforward manner. Indeed, it is a challenging task to develop structural and measurement models, where factors and measures are orthogonal in the ideal case, but at least exhibit a lowest degree of collinearity. Statistical analysis techniques such as *correlation*, *regression*, and *factor analysis* deem useful to sample, validate, and tune the underlying model in early evaluation runs in order to maximize validity throughout the overall process.

Table 4 relates these three sets of dimensions (with their main criteria) to the methods reviewed in the previous sections. Each of the dimensions (technological, psycho-pedagogical, and organizational/social) can be broken down into its main groups of constructs, as listed in the first column. The second column provides the selection of methods that have been used in the past and that we deem most appropriate for their study.

Table 4 Evaluation dimensions and recommended methods

Dimension	Group of constructs	Key methods
Technological	Openness	Questionnaires
	Responsiveness	Interviews (incl. storytelling)
	Security	Desk research (documentation)
	Scalability	Nominal group, Delphi
	Documentation	Inspection methods
	Interoperability	User tests
	Accessibility	Monitoring data (incl. web analytics, CAM)
	Availability, reliability	Observation
	Quality (content and UI)	Unit tests
	Effectiveness	user-based evaluation: behavioral measures, observations, and questionnaires
	Efficiency, satisfaction	
	Enjoyment	
Organizational/ Social	Trust	Questionnaires
	Social usefulness	Interviews
	New connections	Desk research
	Sharing	Monitoring data
	Privacy	Social network analysis
		Clustering
Psycho-pedagogical	Meta-cognitive	Questionnaires
	Motivation	Interviews
	Behavioral	Nominal group, Delphi, focus group
	Recommendations	Monitoring data
		Observation
		Quasi-experiments (relevance accuracy)

The PLE evaluation is ideally conducted in cycles of planning, actual evaluation, and reflection on results. A useful vehicle for this can be found in form of case studies and—concluding the final cycle—a cross-case analysis. Case study is a generic term for the investigation of an individual group or a phenomenon (Bogdan and Biklen 2006). Case studies are often used for exploratory research, but the technique can be varied and adapted to include the multi-method mix proposed above for the unified PLE evaluation framework.

While the techniques used may vary, the distinguishing feature of case study is the assumption that human systems develop a characteristic wholeness or integrity and are not simply a loose collection of traits. This approach enables researchers to investigate a given phenomenon to a much greater depth, bringing out the interdependencies of parts and emerging patterns. Besides, case study has the potential to accommodate the value context of the enquiry, is flexible to accommodate unanticipated events, does not attempt to generalize, and admit the problems of researcher bias in various ways (Nisbet and Watt 1984). Nonetheless, the inability to accommodate re-observation is a major cause of concern.

The final cycle of the cyclic evaluation process depicted above in Fig. 3 can then be concluded with the cross-case analysis. A cross-case analysis is "a qualitative, inductive, multi-case study that seeks to build abstractions across cases" (Merriam 1998, p.195). It is used to identify and compare patterns of similarities and differences across individual cases resulting in meaningful connections. Most importantly it empowers all stakeholders to access new knowledge from a rich holistic point of view (Khan and van Wynsberghe 2008).

There are two well-known techniques to carry out cross-case analysis, namely, variable- and case-oriented approaches (Ragin 2004). There are other techniques as

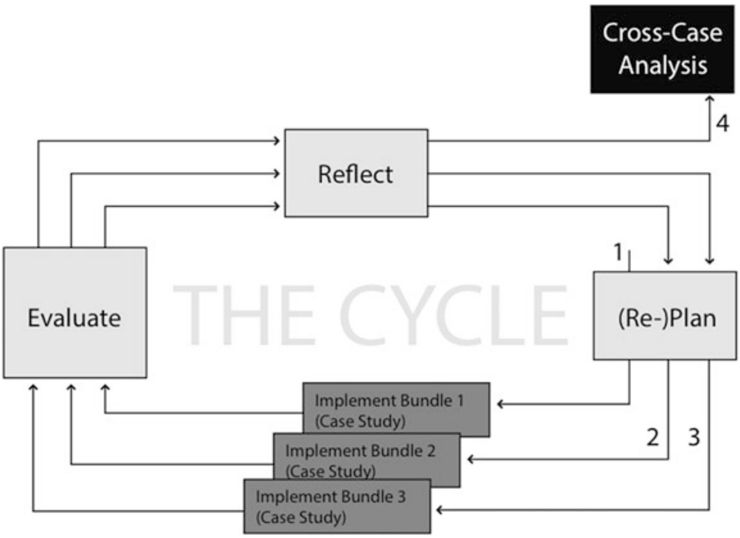

Fig. 3 Evaluation cycle for PLEs

well but are generally derived from the aforementioned ones. The variable-oriented technique focuses on comparison of identified variables across cases in order to delineate causal relationships. The case-oriented approach enables researchers to make sense of causal similarities between different cases by comparing them using visualization techniques such as stacking cases (Miles and Huberman 1994), thereby enabling the identification of new social phenomenon.

There are a number of ways in which case-oriented cross-case analysis could be carried out, namely, most different design (Przeworski and Teune 1982), typologies, multi-case methods (Smith 2004), and process tracing (George and Bennett 2005). The first two are of particular interest for PLE. The aim for adopting cross-case analysis for studying the implementation of PLEs across settings is to identify similarities in a diverse set of cases, which is what most different design offers. Additionally clustering of cases might also be relevant to identify and compare patterns and process pathways to seek typological regularity. We recommend the adoption of an iterative case study design with multi-method data collection to triangulate empirical findings. Cross-case analysis should be performed towards the end of a series of evaluations to obtain a holistic view on the outcomes of deploying PLEs (cf. Fig. 3).

General Discussion: Qualitative Versus Quantitative

In the foregoing sections we present an array of quantitative and qualitative methods for data collection and analysis. The selection of a particular type of method depends on individual researchers' assumptions, values, and expertise.

Some researchers defy the value of quantitative data with the argument that numbers cannot tell us anything, insisting on capturing solely qualitative data. Any method fundamentalism is wrong, not least in the light of a postulate for a wide repertoire of research skills among researchers. Still such standpoint is often found in practice, particularly by those critics instigating methodological discussions with the aim to dismantle or even discredit a particular piece of quantitative work they do not agree with.

It is in our opinion, however, not that simple: Methods cannot be differentiated into good and bad, and if a particular method fails to provide results (or even more often: results beyond tautologies), then this probably says more about their competent handling, rather than their validity or reliability. Exceptions prove the rule, of course.

In our view, there are two aspects to consider that influence methodological choices. First, it all depends on *why* the evaluation is needed, *what* the goal of the evaluation is, and *who* the recipient of the evaluation data is. For example, if the target is to feed back into psycho-pedagogical or technological development, qualitative means can provide deeper insights on what has gone wrong, what works, and what leaves room for improvement. Moreover, qualitative methods bear the potential to discover, *why* this is the case.

Furthermore, which approach to adopt depends on the *phase* of a research study. Qualitative approaches are particularly useful for exploring a topic and its phenomena in their context. They help in forming hypotheses and build understanding. Once such understanding is reached, however, more targeted questions can be posed. Also, if a phenomenon or an application is potentially relevant to a larger number of people, then it is well justified to conduct a quantitative follow-up to see if the qualitative findings, suspected dependencies, effects, and other observations hold when scaling out. Qualitative methods do not scale very well, which can pose a problem when the target is to, for instance, to assess the effects of an intervention on a full university, an entire company, or the general population.

This chapter aims to support researchers in determining which method they need, depending on purpose ("TOPS") and phase (from case-to-case to cross-case). It provides a rich repertoire of different methods for the multi-method, multi-perspective mix, and it helps in combining the strength of different approaches into a unified evaluation.

As can be seen from the review of the methodological state of the art, the frontiers in technology-enhanced learning are much more complex than the mere differentiation of quantitative and qualitative suggests: "mediated" observation using monitoring data, pictogram-based methods for affect measurement, quasi-experiments for relevance evaluation, and the like start blurring these boundaries and start claiming their own place in the standard canon of methods.

It is worth mentioning one class of methods listed in the chapter in particular, as it stands out through the paucity of research in the area of PLEs: While emotions and affects can play a critical role in influencing a learner's motivation to engage in technology-enhanced learning activities, this experiential aspect tends to be not only overlooked, but also under-researched.

At the turn of millennium, the psychological research on emotions has been rekindled, thanks to the work of psychologists such as Klaus Scherer (2005; "emotion wheel") and James A. Russell (2003"core affect"). Coincidentally, this resurgence of interest in emotions and affects has resonated with the shift of emphasis in HCI around the same time, moving from cognitivist-behavioral performance-based usability to phenomenological-reflective experience-oriented user experience (UX) (Law et al. 2009) .

Alongside with this change of emphasis is the revived tension about the relative importance of qualitative and quantitative methods. This issue is actually an age-old debate in the realm of measurement theory. In brevity, some UX researchers argue that experience is holistic and cannot be reduced into components to be measured; any attempt to put down a number to infer the type or intensity of an emotion is methodologically flawed and inherently meaningless. In contrast, some other UX researchers believe that the process of experiencing/experienced emotions can be modeled like cognitive processes and thus they are measurable. These arguments have significant implications to the selection of evaluation methods for assessing the impact of interacting with technologies (Law et al. 2014).

Above all, putting aside the issue about the quantifiability of user experience, the main point we want to stress is the high relevance of emotions and affects to the design and evaluation of learning environments. Both positive (e.g., fun, pleasure, engaged, liberating) and negative (e.g., anxious, defeated, frustrated, fear) emotions can substantially shape the effectiveness of any type of learning situations, including PLEs. Consequently, due attention should be heeded to this overlooked experiential aspect.

Conclusion and Future Work

Developing an evaluation framework for PLEs is challenging, since technological, organizational, psycho-pedagogical and social aspects need to be considered in an integrated manner and with a diverse set of stakeholder perspectives being taken into account.

Our attempt was to propose a unified framework encompassing the main valid constructs (derived from relevant theoretical models), yet at the same time providing a flexible and adaptive methodology that is capable of accommodating the changes that are inevitable in an emerging field.

In order to achieve this, we have elaborated an integrated framework that is by nature case study based and follows a multi-method approach. Furthermore, we recommended concluding the cyclic evaluation with a cross-case analysis in order to consolidate data from different contexts so as to establish a holistic view.

A number of metrics and possible methods have been identified and located in the proposed unified framework. The metrics, criteria, methods, techniques, and tools proposed are subjected to further refinement and improvement. A process model ensures the possibility to do so in a well-defined manner.

Obviously, more research efforts are called for to investigate the complex phenomenon of PLE—and this contribution provides the methodological basis on which such future endeavors can be built.

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Case Study 1: Using Widget Bundles for Formal Learning in Higher Education

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Abstract Formal learning in higher education creates its own challenges for didactics, teaching, technology, and organization. The growing need for well-educated employees requires new ideas and tools in education. Within the ROLE project, three personal learning environments based on ROLE technology were used to accompany "traditional" teaching and learning activities at universities. The test beds at the RWTH Aachen University in Germany, the School of Continuing Education of Shanghai Jiao Tong University in China, and the Uppsala University in Sweden differ in learning culture, the number of students and their individual background, synchronous versus distant learning, etc. The big range of test beds underlines the flexibility of ROLE technology. For each test bed, the learning scenario is presented and analyzed as well as the particular ROLE learning environment. The evaluation methods are described and the research results discussed in detail. The learned lessons provide an easy way to benefit from the ROLE research work which demonstrates the potential for new ideas based on flexible e-learning concepts and tools in "traditional" education.

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Introduction

This chapter focuses on using Personal Learning Environments (PLEs) in formal learning in higher education (HE). Here, formal learning means that the PLE and its widget bundles support the established, "traditional" way of teaching in a lecture. The teaching and learning activities are not newly created and centered on the PLE, but the PLE extends the existing teaching context and provides additional activities within. Therefore, the primary audience of PLEs consists of teachers instead of students. While this might sound as a contradiction to the paradigm of *personal learning*, we argue that a valuable goal of ROLE technology is to increase the range of interactive and social learning opportunities.

In the ROLE project, three test beds served to explore such a setting:

- RWTH Aachen University, whose department of mechanical engineering is ranked at 17th in the world (best in Germany) by the QS University Subject Ranking in 2012.
- The School of Continuing Education (SOCE) of Shanghai Jiao Tong University (SJTU), a blended learning institution whose students are young, working adults who study part-time.
- Uppsala University, Sweden's oldest university founded in 1477, which has got a long tradition of distance education.

Albeit all three test beds are placed within higher education, they cover quite different contexts. For instance, SOCE is located in China. With its approach to teaching and learning based on the Confucian tradition (Zhang 2007), it is quite different to RWTH as an example of a Western university. Also, SOCE students study part-time, most of them have a job and family, while RWTH students are younger full-time students. Furthermore, SOCE is a blended institution, where a significant part of teaching and learning takes place online, while RWTH is a traditional on-campus university. In contrast, while Uppsala University is also for the most part an on-campus university, it offers a wide selection of distance courses with very limited or no on-campus participation required. It proved particularly interesting to investigate what different forms ROLE technology could take in these settings, and it speaks of its flexibility that this was possible at all. Last but not least, the number of participants in the test bed classes differ from 20 (Uppsala Scenario) and 250 (SOCE Scenario) to 1,600 (RWTH Scenario). Growing numbers of students combined with limited resources for teaching are often an important motivation to search for a better support by e-learning tools.

The chapter starts with a review of related work, followed by the description of the test beds in separate sections. In each section, we describe the learning context, the tools and bundles employed, the most relevant evaluations we performed and the lessons we learned. We end this chapter with a brief conclusion that summarizes the main differences and similarities regarding the usage of ROLE technology in the three test beds.

Related Research

The presented approach addresses various recent research issues such as teaching and learning in large classes as well as using cloud services and Web 2.0 applications for e-learning support.

The usage of PLE technology has been investigated by a few studies, albeit in small-scale environments. Blees and Rittberger (2009) describe the usage of a learning environment assembled from different Web 2.0 services in a course on "Social Software." The 13 participants were familiar with Web 2.0 technology and rated the usage of the service relatively high. The 26 case studies reported by Minocha in (2009) mainly cover studies where students worked with a single Web 2.0 service integrated into a PLE. Law and Nguyen-Ngoc (2008) present a social network and a content analysis of interactions in a collaborative learning environment. Their data show that some students profit from such environments, but not all students. The challenge of teaching large classes has been a research issue for many years (cf. Leonard et al. 1988; Knight and Wood 2005). The more technical background of building e-learning tools from Web 2.0 components is being discussed in Palmér et al. (2009). The approach uses six dimensions for the mapping of Web 2.0 applications to personalized learning environments. The capabilities of ROLE-based cloud learning services are investigated in Rizzardini et al. (2012). The evaluation shows that a cloud-based learning support with ROLE environments is possible but the learners may need introduction and time to be familiar with interactive e-learning tools. The particular aspect of navigation guidance for learning questions in Java programming is discussed in Hsiao et al. (2010).

While these studies shed light on specific questions regarding of PLE, no prior work has investigated how a single PLE platform can be adapted to suit the needs of different formal higher learning scenarios and how it performs in such scenarios over long periods of time and with significant number of users. More specifically, the case studies described in this chapter add to the mentioned evaluations insofar they investigate (1) the use of learning environments that contain components apart from Web 2.0 tools (in a narrower sense), (2) with large user groups (3) of both teachers and learners (4) from different cultural contexts. The results are ultimately relevant for ROLE-based environments but can easily be transferred to other kinds of environments and systems.

RWTH Aachen University: ROLE for Full-Time Students in Large Classes

Large classes at universities create their own challenges for teaching and learning. Audience feedback is lacking. Individual needs of students are often hard to address sufficiently. At RWTH Aachen University, a ROLE-based knowledge map learning tool was developed and embedded in the context of a large class course for computer science in mechanical engineering. The objective of this PLE was to support individual learning of students during exam preparation. Theme-based exercises have been developed and evaluated. The tool was grounded in the notion of self-regulated learning (SRL) with the goal of enabling students to learn independently.[1]

Learning Scenario

The Institute of Information Management in Mechanical Engineering (IMA) of RWTH Aachen University offers a lecture about computer science in mechanical engineering, which was attended by 1,600 students in 2012 (see Fig. 1). The lecture

Fig. 1 Lecture for computer science in mechanical engineering given in the RWTH auditorium maximum (made by David Emanuel)

[1] Parts of the content and information of this section have already been published by Vieritz et.al. (2013).

is part of the curriculum for the bachelor degree in mechanical engineering (second semester) and business engineering (fourth semester).

In 2012, the lecture focused on object-oriented software development with Java and on software engineering (for details see Ewert et.al. 2011). The lecture is accompanied by a programming lab, a group exercise, and exam preparation courses. In the lab, the students are taught to program Lego NXT Mindstorms robots with Java. They are working in small teams of two students in problem-based learning scenarios. They were requested to program a robotic gripper inspired by industrial robots.

The robots simulated pick-and-place machines (P&Ps) as they are used for surface-mount devices (SMDs). The resemblance to industrial robots was meant to result in a better understanding of mechanical engineering principles by the students. To support the Java programming language implementation on the NXT controller, LeJOS was used (Solorzano 2012).

The lab took place together with the lecture during the summer term 2012. The lecture period started in April and ended in July. Exam preparation courses were provided in September just before the final test. These courses offered the students the possibility to train the addressed competences in smaller audiences.

All parts of the course received good feedback and results from the students within the evaluation. Nevertheless, the students were challenged by learning in large classes in the programming lab. Individual support was often requested, but the number of supporting tutors was limited.

Therefore, one important objective for the course revision in 2012 was a better support for individual learning with e-learning tools. The e-learning system L2P of RWTH[2] is already used as a Learning Management System (LMS) in the lecture, the group exercises, and the lab mentioned above. However, additional learning support was requested to assist students in and out of class, but particularly when learning autonomously. Two major challenges of the described scenario are:

- A wide range of pre-course programming skills among the students.
- Individual support for learning with limited resources for teaching personal.

To meet these requirements, a Web-based e-learning test bed was designed and implemented which supports different kinds of learning situations like SRL, peer-instruction learning, and email support by tutors. The test bed learning content ranged from exam preparation exercises for all students to additional background information for advanced students. It extends the L2P learning room with interactive learning capabilities and is described in the next chapter.

[2] http://www2.elearning.rwth-aachen.de/english

The Personal Learning Environment

The development of the interactive e-learning platform was part of the ROLE project. Beginning with the summer semester 2010, a previous version of a Web 2.0 Knowledge Map (WKM) was enhanced with ROLE technology. In particular, it was transferred to a widget-based environment (cf. von der Heiden et al. 2011), that is a bundle of widgets interacting via ROLE Inter-widget Communication (IWC) (Renzel 2011).

The WKM is an electronic reference book, which can be regarded as a kind of improved Wiki system. It won the second prize in the 2010 International E-Learning Association Awards, in the category "Academic Blended Learning." The application supports students in looking up factual knowledge. Students can search for articles by entering topic keywords and by navigating from their current article to related articles following hyperlinks. It is based on semantic net technology, where hyperlinks are not just links, but belong to predefined categories, each bearing a meaning, as a named relation. The object-oriented content organization knows classes and objects of knowledge. A class is a predefined template for a knowledge object such as an "Exercise" and its realization. Similar to a Wiki, the WKM supports the creation of new content. A dedicated rights management allows the usage of different roles as authors, administrators, and users. Authoring is currently restricted to lecturers and tutors. Additionally, the content visualization capabilities based on hypermedia support nonlinear learning approaches.

For the ROLE project, the WKM was redesigned as an interactive learning tool and as a test bed for ROLE technology in a higher education scenario. The new design was motivated by the following main goals:

- Guide and support students in a self-regulated and nonlinear learning process.
- Motivate, introduce, and provide high-quality basic knowledge using multimedia material.
- Provide an interactive reference book on lecture contents for exam preparation.
- Support interest-based real-time communication and collaboration in learner communities.

Thus, the former WKM has been extended with a chat to provide theme-based learning communication between users. A learning history accomplishes the setup. Built up with ROLE technology, the "new" WKM is composed of three intercommunicating widgets (see Fig. 2), namely:

- Web 2.0 knowledge map widget for accessing and reading topic articles as well as exam exercises.
- Chat widget: general or topic-related group chats and presence information for individual tutor support or peer-to-peer instruction.
- History widget: tracks individual learning activities and shows personal history of visited topics.

Fig. 2 Screenshot of RWTH testbed with Web 2.0 knowledge map, chat and history widget

The test bed scenario was deployed for the course lab and also for the students' individual exam preparation in August and September. The WKM aimed to provide the students with information covered in the lecture and in the lab. It was filled with additional SRL-adapted content thus focusing on typical SRL situations such as the exam preparation phase. It contained explanations and motivations for notions, definitions, or examples, e.g., for basic Java programming constructs. Background information was provided as well, e.g., about software installation. Exercises for exam preparation were associated with lecture content. The presentation and organization of the WKM followed the paradigm of object-oriented analysis and design in software development. Relations between objects and classes of objects were visualized (see Fig. 3) to underline knowledge associations. Functionalities for annotations, remarks, and feedback were provided.

The second widget, a chat widget, was embedded to offer students the possibility to ask and answer topic-related questions. Other students answered the posed questions while a tutor moderated the chat.

Finally, a history widget was embedded into the learning environment. It supported the backward navigation within the environment by offering the last five activated knowledge objects. The widget uses data from the WKM widget to support the learner with his or her own learning history.

The WKM was maintained by the IMA, the test bed was hosted by the department of information science at RWTH. Access to the WKM was granted via the login for the course lab. For the first time in the course's history, this WKM learning environment gave students the opportunity of individual support during their exam preparation.

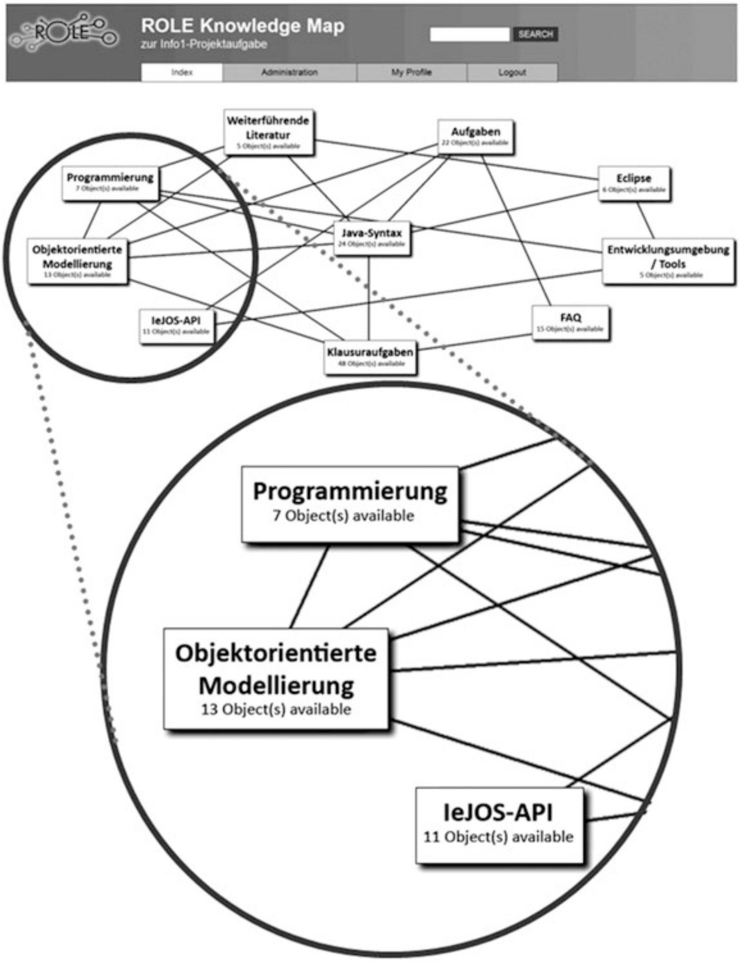

Fig. 3 Screenshot of the Web 2.0 knowledge map RWTH (start page)

Technical realization: The WKM has been bundled with a chat widget and a personal history widget. The chat widget allows learners to communicate with instant chat messages and to see the online status of other learners. It is integrated with the WKM by automatically creating a separate chat room for each topic that is currently read by the learner. Learners can see the topics of other learners and can quickly join them in the topic-specific chat room to discuss their understanding of the topic and how it relates to their current work. The personal history widget records the topics visited in the knowledge map and allows quickly navigating back to previous topics. The three widgets interoperate based on IWC; the following examples of widget communication events demonstrate a selection of implemented interactions:

- *Entering a topic-based chat room on topic selection*: When a student selects a topic from the WKM, a corresponding chat room is entered in the chat widget. At the same time, the student's online status is changed to the new topic in real-time and visible to and clickable for other students.
- *Following a user's activity*: When a student clicks the online status of another student, he navigates to the corresponding topic in the WKM, in turn triggering an event to enter the corresponding topic-specific chat room.
- *Real-time updates of learning history*: When a student selects a topic from the WKM, the selected topic appears at the top of his or her personal history.

Following the overall ROLE approach of open standard compliant widget-based learning environments, the WKM test bed was implemented involving the following enabling technologies:

- OpenSocial[3]: OpenSocial is a set of common application programming interfaces (APIs) for Web-based social network applications developed by Google along with MySpace and a number of other social networks. Applications implementing the OpenSocial APIs will be interoperable with any social network system that supports them. The ROLE version of the WKM is deployed in Apache Shindig,[4] the open-source reference implementation of an OpenSocial-container.
- Extensible Messaging and Presence Protocol[5] (XMPP) is an open standard technology for real-time communication, which powers a wide range of applications including instant messaging, presence, multiuser chat, and collaboration. The ROLE version of the WKM offers XMPP-based features such as topic-based chat rooms and real-time information on current presence and learning activities.
- Inter-widget Communication (IWC) (cf. Renzel 2011; Zuzak et al. 2011): With IWC, individual widget functionalities can be combined to realize complete application workflows. ROLE leverages various forms of both local and remote collaboration and communication among. The ROLE version of the WKM demonstrates local IWC using technologies such as PMRPC[6] and Google Gadget PubSub being part of the OpenSocial specifications. A basic form of remote IWC was demonstrated with the new WKM chat functionality.
- Monitoring: All learning activities are tracked by the history widget and persisted as Contextualized Attention Metadata (CAM; cf. Schmitz et al. 2011). The ROLE version of the WKM was the first test bed producing real-life usage data, which, later on, served for producing recommendations and as a basis for further development of the WKM and ROLE technologies in general.

[3] http://www.opensocial.org/

[4] http://shindig.apache.org/

[5] http://xmpp.org/

[6] http://code.google.com/p/pmrpc/

A detailed description of the ROLE framework technology can be found in chapter VIII "Lessons learned from the development of the ROLE framework."

Evaluation and Methodology

Additionally to the tool development, a test bed evaluation was designed to analyze how the environment influenced the students' learning processes. The RWTH ROLE test bed work in 2012 was initiated with a Web-based survey that aimed to collect details about the students' experience with e-learning and SRL at the beginning of the lab in April 2012. The ROLE widget environment was introduced to the students during the second week of their studies. The enriched ROLE-based learning environment offered additional support for improvement in SRL opportunities. It also provided information about programming in general, related tools, modeling as well as Java as such. Around 1,600 students participated in the course. All students were informed about the ROLE-enhanced learning environment via several announcements during lectures and labs as well as via email. During the standard midterm teaching evaluation, a short ROLE-related survey was issued. At the end of the lecture period, the ROLE test bed was also adapted for individual exam preparation during summer time. Finally, after the exam, educational staff was interviewed to evaluate the environment and its application within the course. The lab sessions took place in the largest computer pool of the RWTH which is equipped with approximately 200 workstations. This, however, restricted the maximum number of students that could attend the lab in parallel to 200 students who then worked with 100 Mindstorms NXT robots. Since those 100 robots could not be dismounted and reassembled in each lesson, the lab was based on a standardized and preassembled robot model.

The ROLE environment was used during the lab time from April to June. Usage grew significantly in September when the students started their individual exam preparations some weeks before the exam. The access peak was reached in the days just before the exam when students switched to "power learning." This is illustrated by Fig. 4 showing the number (by day) of accessed knowledge objects. The number of generated views corresponds with the access rate and indicates the intensity of usage by the students. Figure 4 underlines the exam-oriented learning during the preparation that restricts the leeway in learning and thus the autonomy of the learner. This characteristic learning activity trend has been repeated during the next exam period in March 2013.

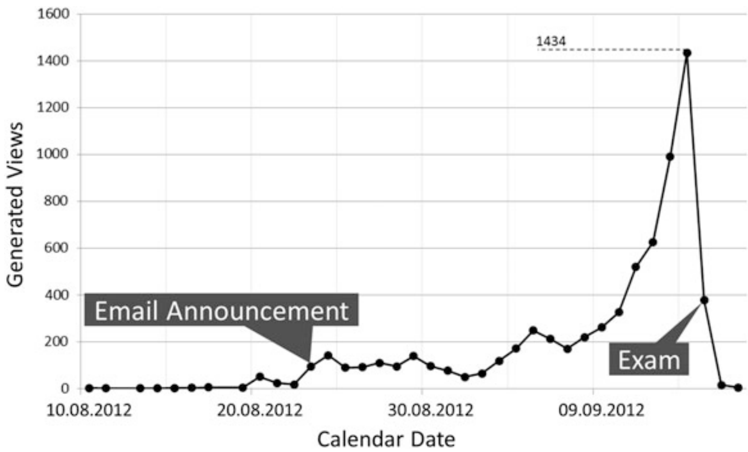

Fig. 4 Requested knowledge objects by day in the RWTH testbed

Results

In June 2012, before the summer break (i.e., at the end of the lab session but before the exam preparation), the students were asked about the usefulness of the e-learning environment and rated it positively. 162 stated that the application of the computer-based learning environment was useful. On the given scale from 1 (strongly disagree) to 5 (strongly agree), the arithmetic mean (AM) of the results was 3.7 with a standard deviation (SD) of 1.3. Since 3 would be neutral, the students evaluate the environment positively without being overwhelmed.

After the course, the environment has been evaluated by the teaching staff. We conducted four interviews, three of them with student assistants who acted as tutors within the practical exercise and the exam preparation. They were responsible for adding contents to the knowledge map and for solving technical issues. One interview was conducted with the lecturer who was responsible for the overall coordination and who was involved in the planning and conception of the whole course. In the interviews, we asked the participants to rate several statements on a scale from 1 (strongly disagree) to 5 (strongly agree) and to explain their ratings. Moreover, we asked them to comment on the strengths and weaknesses of the environment and to suggest improvements. The students' positive judgment of the environment has been corroborated by the teachers. For each statement, the arithmetic mean (AM) and the standard deviation is given (SD) (while interpreting these measures, one has to keep in mind that only four persons rated the statements):

- The environment was useful for the students. AM: 4.25, SD: 0.43
- The environment was useful for me in my role as a lecturer/tutor. AM: 4.00, SD: 0.71
- The students reached the learning goals better because of the environment. AM: 4.00, SD: 0.71

- I reached my teaching goals better because of the environment. AM: 3.50, SD: 1.12
- I would advise the students to use such environments more often if they had access to them. AM: 4.75, SD: 0.43
- I would use such environments more often for teaching if I had access to them. AM: 4.67, SD: 0.47
- I would use such environments more often for learning if I had access to them. AM: 3.25, SD: 1.79 (This is an interesting result: Why do the lecturers/tutors rather advise their students to use such an environment than use it themselves? The interviewees answered that their personal learning style is not optimally supported by such an environment, because firstly they prefer not to browse through learning contents but to study textbooks and other material, in particular exercises and exam questions from previous semesters, from beginning to end. Secondly, they prefer using pen and paper over doing all exercises with the computer. Therefore, they request an export to PDF so that they can print selected parts of the material.)
- I consider the environment used within this course as a didactically sound means. AM: 4.50, SD: 0.50

According to the interviewees, the strengths of the environment were, firstly, that the knowledge map gave a clear overview on the course contents and their inter-relationships. The students got a starting point for browsing through the material and exploring the themes independently. Questions could be answered by pointing to specific objects on the knowledge map, and students could (and did) answer their follow-up questions themselves by exploring the surrounding/linked objects. Thereby, the autonomy of the student was effectively supported. Secondly, the chat widget allowed fast feedback from the students. Questions could be answered immediately. Since all students could read the answers, questions did not have to be answered twice. Thereby, the tutors' explanations became more efficient. The tutors saved time for helping with truly individual problems. Thirdly, the environment improved the communication among the students and, thereby, the collaborative learning. After a short time span, the students began to answer questions asked by other students. Fourthly, the environment rendered the students more flexible regarding their time management and learning speed. They were able to repeat lessons and exercises without losing track of the course or thwarting others.

Concerning weaknesses, the interviewees mentioned technical and usability issues; in particular regarding the administration of the environment and the adding of new contents to the knowledge map. These issues have to be solved, but they do neither affect the concept nor the general design of the environment. Moreover, the interviewees propose the following extensions of the environment:

The chat widget should be exchanged or supplemented by a forum for general questions and by a commentary function for the elements of the knowledge map. This would improve the linking of contents with questions and comments. They consider a learning planner consisting of a simple to-do list with links to exam-related material and topics, self-tests and a visualization of the current level of knowledge/exam preparation progress (related to the self-test results) as extremely useful. The interviewees agree that the contents are the most important feature of the environment. These have to be updated regularly. So far, the contents of the knowledge map are explored by browsing. An additional search engine for the direct search of specific content would be reasonable. One interviewee deems a recommender system that recommends related external material useful.

One aim of offering the ROLE environment was to support SRL. Has this goal been reached, that is, did the environment effectively support self-regulation? The interviewees claim that this is in fact the case. While in the beginning, a lot of trivial questions were asked, the students were able to find the answers to such simple questions themselves soon. (The question is, however, whether we can attribute this development to an improvement of self-regulation or rather to a learning effect regarding the course contents.) The interviewees considered it important to support SRL. They estimated that by far, most of their students had medium SRL-level. They correlated the SRL-level with the general knowledge level and acknowledged that students with a high SRL-level learned better and faster. However, as tutors and lecturers they generally preferred to teach students with a medium SRL-level over students with a high SRL-level. They justified this preference as follows: A tutor was supposed to lead interesting discussions with high SRL-level students. However, they did not need a tutor that much and therefore did not get in close contact with them. Often, teaching did not really take place. Moreover, these students tended to be good students that asked difficult questions. A teacher had to be well-prepared and feel certain on the course topic to cope with these questions. This made it sometimes harder to teach students with a higher SRL-level.

Medium SRL-level students were intelligent but still requested interaction with a teacher. The teacher got in contact with them, observed the learning progress and saw the positive effect of explanations and assistance. The interviewees found this very rewarding.

The interviewees considered that a low SRL-level is correlated with rather low learning success.

Teaching students with a general low level was considered to be cumbersome and not very rewarding. Feedback given through the environment was recognized by teachers as very important. The interviewees emphasized the role of the chat (or a forum). Feedback was deemed important for estimating the students' progress and thus adjusting interventions. Moreover, it makes teaching more satisfying.

Conclusions

The evaluation proved the necessity of intensive promotion for new and additional e-learning tools. Tool objectives and advantages must be clearly communicated (at the right time) to the students. Nevertheless, only a minority of all students had used the test bed for a longer time. Here, guidance with learning questions as in (Hsiao et al. 2010) may motivate students and foster communication.

Until now, overview and learning guidance is given by the visualization of topic relations on the start page, the hierarchical and object-oriented organization of knowledge in the map and the linking of knowledge objects. The evaluation proved that the environment supports SRL and collaborative learning in large classes. The answering of student questions was easier via the chat widget than by email as all students were able to see the answer. Additionally, the chat fostered student-to-student support. Even if the test bed offered support for early learning, the peak of usage was reached just before the exam. It indicates the students' remaining in power learning.

The test bed was implemented as a cloud learning application combining widgets as services in an overall application and using IWC for communication between the widgets. Since different people were responsible for the particular widgets, it was sometimes hard to fix problems, e.g., when a server was not accessible.

So far, the test bed was aimed to demonstrate the possibilities of ROLE technology in large classes. The demonstration was successful and further development has to focus more on the learning requirements of students. Therefore, future improvements are seen in better communication and feedback support to strengthen, e.g., learning motivation. Suggested improvements comprise firstly a better collaboration support that can be implemented by adding improving, topic-related communication (forum, notepad linked to contents of knowledge map) and secondly a better SRL-support that can be implemented by adding a learning planner that supports planning (to-do list) and reflection (self-tests, visualization of progress). The offering of learning strategies such as learning questions (Hsiao et al. 2010) within the learning tool may provide new advantages and motivation for the students.

Lessons Learned

The evaluation resulted in the following recommendations. These recommendations are focused on the context of large classes in HE:

1. New e-learning tools—especially if in concurrence to existing solutions—require intensive promotion. Students need a clear motivation and benefits for the own learning objectives. Multiple announcing will be helpful incl. situations when students will "hear" the message. Here, the usage of the exam preparation tool was fostered with an announcement only some weeks before the exam when student's individual learning situations corresponds to the "message."
2. If a new e-learning tool must fit to an already existing process of learning and organization in HE, a good idea is better support for student's individual learning process, e.g., when the student is not present at the university and not in contact with tutors.

3. During their learning workflow, students are interested to ask and answer questions. Therefore, e-learning tools for individual exam preparation are more attractive if combined with communication services as chats and email. Peer-to-peer communication within the students is welcome and can reduce the effort for mentoring by tutors. Even, communication can provide qualitative feedback for learning content as exercises and solution samples.
4. One chat for all—instead of multiple chats for different content—provides more communication activity. Chat activities can link to the corresponding content to clarify the context for questions.

Outlook

The design of the complete course has been analyzed after the exam in September 2012. The usage of the ROLE test bed, the participation and other indicators has shown that the students' SRL capabilities do not meet the presumptions for the lab design. On the one hand, the students' pre-skills in programming differ significantly; as a consequence, the strict schedule of the lab was often too slow or too fast for them. On the other hand, the capabilities for self-organizing teaching material from different sources are not very well developed and students expect to have all pieces of information at one place. The lab learning activities were often frustrating for the students and tutors.

Therefore, we developed completely new teaching material which guides the students through the learning process. In the beginning, the basics of programming are explained in every detail and step by step, the autonomous work phases of the students get longer and longer. This teaching material supports an individual schedule of learning activity, as well, which corresponds better to different programming skills. First evaluation results show that the students are much more interested in the learning activities. Even the tutors prefer the new learning design since the students are motivated and ask interesting questions.

Shanghai Jiao Tong University: ROLE for Employed, Part-Time Students

The SJTU case study set out to address the issue of using Personal Learning Environments in adult higher education. It is associated with the SOCE whose blended classrooms are based on the Standard Natural Classroom model (Shen et al. 2008) providing face-to-face interaction with the instructor as well as online courses. Its students, mostly adult learners who have a job, take classes in the evening or at the weekend, by either attending in person in the classroom or by watching live over the Web. Improving their competencies via degree education or certificate training enables them to increase their chances in the highly competitive Chinese job market—a market that is also characterized by frequent job-hopping.

Teaching and learning in this case study follows a traditional pattern: it has a teacher-centric focus, with a "broadcast" model, where most students watch the lectures rather passively. The ROLE project, in this instance, has offered SJTU an opportunity to explore and investigate how to use existing available ROLE technologies and tools that could provide a larger amount of opportunities for learner and teacher interaction enabling further potential creative ideas for both parties too. For instance, selected bespoke ROLE tools, such as those offering Voice Recording and Text-to-Speech recognition, allow foreign language students to practice their pronunciation by recording themselves and comparing their speech to the "original" one, thus providing the students with an active learning opportunity.

Learning Scenario

One central aspect of PLEs is that learners can assemble their own learning environments from existing services. They decide which services to use, assembled them, and use it for learning. Such a usage presupposes active, technical-savvy students. From our experience we knew that the students at SOCE do not fall into these categories. Most students have limited knowledge about Web tools (RSS is virtually unknown), only limited time at their disposal, and limited technical expertise. Furthermore, in the Confucian culture of China learning is still very teacher-centered (Zhang 2007), and students are not used to actively contributing to class. We therefore decided to build a PLE according to the learning scenarios specified by the teachers of the courses and make the pre-build PLE accessible to the students.

One example scenario devised by the teacher of the French course is as follows. His course aims at helping the students mastering the first steps in spoken and written French as well as learning about and mastering tools that help students in their working life. These two goals are supported by activities that require using the tools. For instance, starting with an English (or Chinese) sentence, such as "Hello, my name is Tianxiang," the teacher shows how to use a translation tool to get a first rough French translation, and how it can be refined by using a dictionary and spell checker. The French sentence is read aloud by a text-to-speech tool and repeated by the student until it can finally be recorded. This recorded introduction can then be uploaded to social networks. At a later point in the lecture, the students will receive a similar task, such as describing their job without being shown how to use the tools.

Figure 5 contains a screenshot of a PLE, whose basic functionality is similar to the start pages Netvibes and iGoogle. It provides a single page from which the students can access different language related services and sites. The widgets of this PLE facilitate learning a foreign language. For instance, the top right widget performs spell checking; the second one below enables the translation of texts using Google Translate; the third widget accesses a text-to-speech synthesizer; and the bottom left widget allows the student to record and playback his voice.

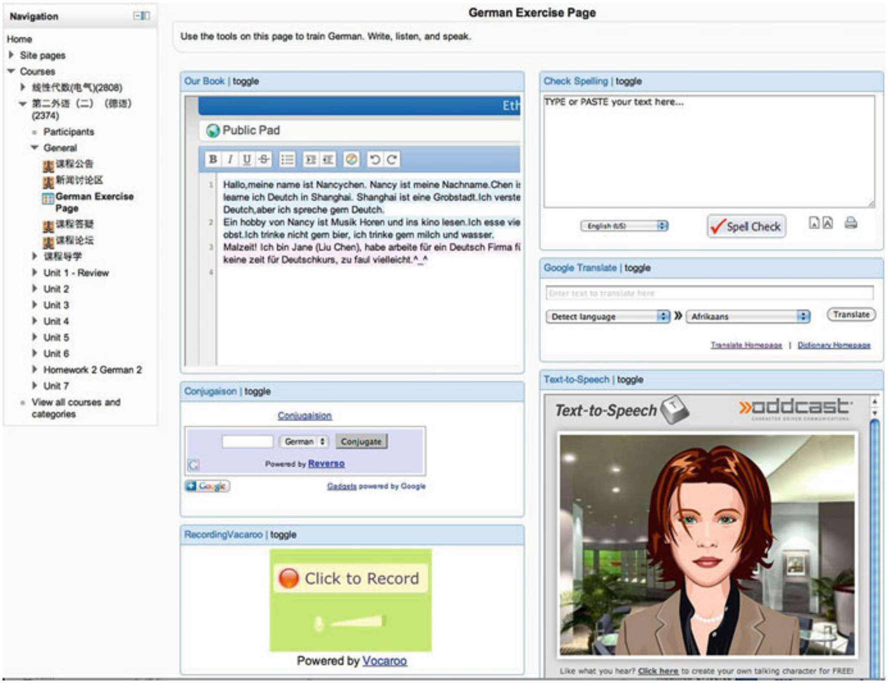

Fig. 5 Screenshot of a SOCE PLE

As another example of a learning scenario, for the course on Data Structures, the teacher wanted to use a PLE that supports rehearsing for the exam. This PLE consisted of a large number of exercises, which trained different concepts in this specific domain, such as linked lists, sorting, etc. The PLE was not tightly integrated into the weekly teaching, but made accessible at the end of the semester, a few weeks before the exams.

To summarize, the PLE usage serves different purposes: the students have a chance to acquire knowledge about existing tools that will be helpful even outside class. Communication in a foreign language becomes facilitated and empowered when supported by translations tools and text-to-speech. The former allow understanding and producing content that learners not yet master due to insufficient vocabulary. The later enables the students to listen to new texts, copied from any source or written by themselves. Together with a recording device, they can compare their speech to the artificially produced one. Furthermore, the PLE provides opportunities to train domain knowledge, in this case multiple-choice exercises that cover topics taught during the lecture (gender of verbs, prepositions, linked lists, sorting, etc.). By reusing existing services we were not required to build our own version of these tools. The free text-to-speech service offers an astonishing quality close to native speakers that would have been difficult to achieve on our own. By assembling all the services in one page, access to these services is facilitated.

The Personal Learning Environment

During the ROLE project, SOCE moved from a self-developed, proprietary LMS to Moodle[7] as the Online Learning Environment. Thus, in a first phase, ROLE technology was developed and evaluated in an additional system (Liferay), which offers widget support. Once the shift to Moodle began, the ROLE evaluations took part in ROLE Moodle extensions. This section provides additional information on the technical realization.

Technical realization: The technical realization of the PLE used at SOCE underwent an early and an advanced phase. In the early phase, SJTU explored first usage of PLE in a technical environment that allowed only rudimentary PLE features, as the advanced features possible at a later time by technology developed in ROLE were not yet available. In the advanced phase, on which we focus in this chapter ROLE technology was developed and integrated into the SOCE learning environment.

Starting in 2011, SOCE moved from its proprietary LMS to Moodle. Moodle is a popular LMS to manage courses that is the de-facto standard among many educational institutions. It is a plugin-based PHP application that can be extended by installing additional modules. These modules have to be installed on a Moodle server by a system administrator. The Moodle view, as shown to students and teachers, consists of a main center area and a rather narrow left column (see Fig. 5 for an example). The center area contains main course resources, such as a wiki page, a forum, a lesson, a quiz, etc.

Moodle's flexibility and adaptability is achieved via visual themes and server side plugins, thus an intervention of system administrators is required every time a change should be done. Teachers and students are not involved in the process of the customization. Teachers, for example, cannot add or remove plugins on their own. Differently from Moodle plugins, widgets are client-side applications that can be added to a system by skipping server side installation, which makes them easy to add.

Our OpenSocial plugin for Moodle allows a simple and teacher/student-driven extension of Moodle's functionality. Once the plugin is installed to Moodle, a teacher can add a "Widget space" to the course, specify a set of widgets for it, and choose whether 1, 2, or 3 column view should be used for widgets display (Fig. 6). The resulting outcome (as displayed to students) is the page with widgets shown in the iGoogle in similar fashion, where students can work with several widgets simultaneously (see Fig. 5).

[7] https://moodle.org/

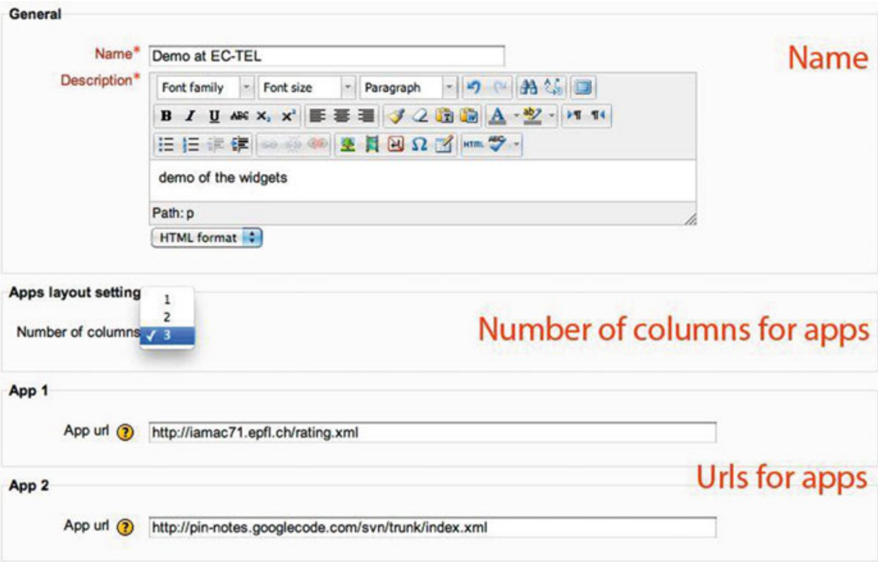

Fig. 6 A teacher creates a space with widgets for a course

From the implementation perspective, the plugin consists of two main parts (Bogdanov et al. 2013). The first part is an engine that renders OpenSocial apps on a page. This engine is Apache Shindig which represents a reference open-source implementation of the OpenSocial specification. The second part is a PHP module that is responsible for a configuration of a page with widgets, adding and removing them to/from the page and gluing Moodle with the Shindig engine. The OpenSocial API provides the standardized way to retrieve and exchange information between different Moodle installations and other social networks, which improves data portability and interoperability. More precisely, widgets can query Moodle for data via the Shindig engine: they can retrieve the currently logged in user, the current course, its participants as well as save and get arbitrary data. The privacy and security are managed via the Shindig engine and it is in the full control of university administrators. However, a widget installed within a course runs on behalf of the teacher who added it and can retrieve/update information that teachers can normally do in their courses. Thus, teachers are responsible for checking the trustfulness of a widget, before adding it into their environments. The ability to retrieve course information and its participants is achieved via OpenSocial Space extension that allows widgets to adapt to the specific context of the course (contextual widgets). For example, a wiki widget can save data for a course and restrict access to only people engaged in this course. The same wiki widget will behave differently being added to another course: it will have a different wiki history and a different list of participants.

Bundles

Two bundles were created by SJTU/SOCE: *Creating an audio self-presentation* and the SRL bundle. Both are available in the ROLE widget store.[8]

Creating an audio self-presentation: The bundle for creating an audio self-presentation in French includes four main widgets: a translator widget, a spell checker, a text-to speech engine and a recording widget, and some additional tools such as a CAM widget, a business dictionary and a conjugation tool. The four main widgets are used to create a self-presentation in French language, the additional widgets are to assist student in his learning activities and to collect usage data. This widget bundle is helpful in a language learning context and can be used to complete different tasks, such as learning vocabulary, improvement of pronunciation, producing of texts and audio-files, etc. The precise functionality of the widgets is as follows.

The Translator widget allows user translating terms or sentences entered. The Translator is linked with a Translator homepage and a Dictionary homepage, which can be called up by user. User, who is a beginner in French, may work with this tool to translate his self-presentation text from English or Chinese into French.

The Spell Checker widget serves to fine tune the translation from the Translator widget or any other (self-produced) text. User may examine his self-presentation text with help of this tool and correct spelling mistakes occurred by translation. To check spelling, type or paste a text into a text entry field and click on a "Spell Check" button.

The Text-to-Speech Engine allows listening to the pronunciation. The user may listen to the pronunciation of his self-presentation text to create or to check his own audio-file made up with the Recording widget. To check the pronunciation, enter a term or a text into a text entry field and click on a "Say it" button. Voice (male or female), language (also British and US pronunciation for English language) as well as additional effects can be selected.

The Recording widget can be used to check user's own pronunciation or to produce audio-files such as pronunciation samples, audio texts, or presentations. With this tool the user may record his self-presentation and compare it with the given pronunciation of the Text-to-Speech Engine.

Some additional tools, such as a Business dictionary and a Conjugation Tool (to check a modification of a verb from its basic form), can be added to the bundle to assist user in his/her learning activities.

SRL bundle: The students at the SOCE of Shanghai Jiao Tong University are young adult learners who typically have a job and family, and this only limited time at their disposal. Also, the students are average learners in the sense that they have little knowledge about how to learn, specifically only limited SRL skills.

For that reason, SJTU together with Koblenz and supported by FIT and Uppsala devised a bundle for supporting SRL (see Fig. 7). The bundle consists of three

[8] http://www.role-widgetstore.eu/bundles

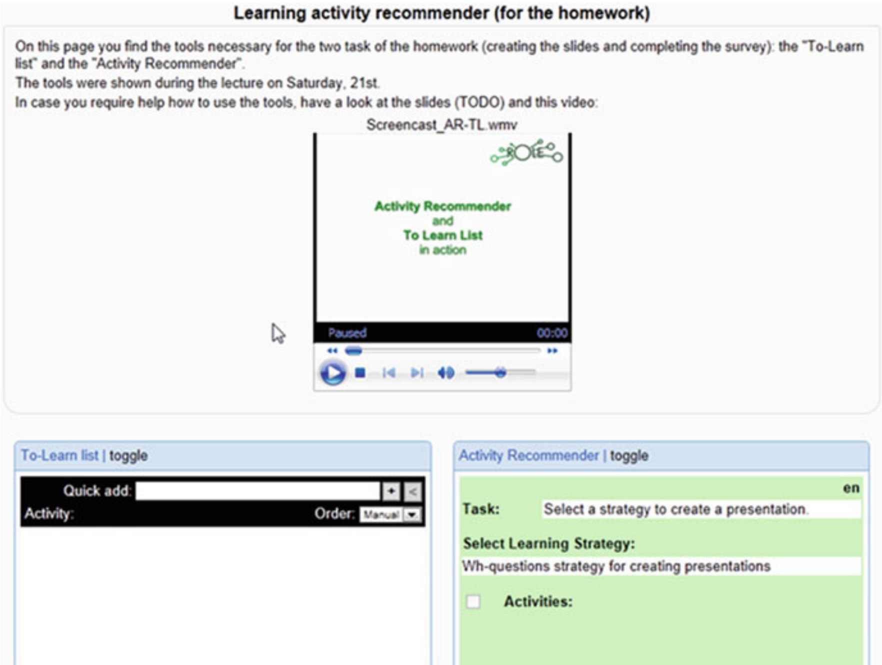

Fig. 7 A screenshot of the self-regulated learning bundle

widgets: the To-Learn list, the Activity Recommender, and the Contextualized Attention Metadata monitor. It also contains a video illustrating the usage of the widgets.

The Activity Recommender widget (bottom right in Fig. 7) gives hints about how to process a given task. In this bundle, the task consists of "how to create a presentation." With the tool, users compile a learning plan consisting of learning activities. The tool shows the current task, matching learning strategies, a list of concrete learning steps, and additional information.

The To-Learn list widget (bottom left in Fig. 7) allows to compile and to modify a learning plan. Users can add, rearrange, delete and rename recommended learning activities or add own activities. The Activity Recommender sends learning activities to the To-Learn list. Students can keep them, or discard them, as they wish.

The CAM monitor tracks how students use the widgets by storing the events send from the other widgets in a central database. This widget is not directly of use for the students in this case, but allows evaluating their usage.

The case study done at SJTU that evaluated the bundle highlighted several points that are of utmost importance when using such a bundle in class. First, due to the novelty of the widgets, students will probably be unclear about how precisely they should use each tool on its own. It is thus recommended that extensive support is provided and that instructions are available that explain the tools. Secondly, the two main widgets in this bundle interact, which is not frequently observed as a behavior in existing systems. This has to be explained in the tool itself. The instructions should cover the usage but also clearly explain the purpose of the widgets, since again the offered functionality is seldom encountered in existing software.

Evaluation and Methodology

The evaluations of PLE usage at SOCE started in 2009 and continued until the end of the ROLE project in 2013. Each semester, PLE technology was used in a number of courses, mostly language learning courses, namely several English courses (English Listening, English Speaking, Critical Reading), and 2 two-semester-long introductions to French and German, but also a Computer Science course (Data Structures). The number of students varied over the courses and semesters. In average, for the language learning about 200 students were inscribed to the courses, about 20–25 came to the lectures in person and about 50 (25%) took the final exams. These numbers are typical for the second language (which is deemed as rather unimportant by the students). About 1,200 students per semester took part in the Computer Science course, with a similar percentage as for the language learning courses of students participating in the final exams. In each course, an example PLE was assembled by the teacher, supported by a team of researchers. In the language learning courses, the PLE was introduced and used in class, and the students were expected and encouraged to use it outside class. In the Data Structure course, the PLE was created at the end of the semester and students were supposed to use it for preparing their exams.

Results

Results from the PUEU surveys: The survey used at SOCE is based on the Technology Acceptance Model (TAM, cf. Venkatesh and Bala 2008) and consists of a set of statements that measure the Perceived Usefulness and Ease of Use (PUEU) of PLEs. The PUEU questionnaire has therefore constituted the “core” part of the surveys used among the users (educators, learners, employees, trainers, etc.) of the ROLE test beds. Naturally, the rest of the questions included in these surveys have been targeting the specific context of each test bed. At SOCE, surveys were created for delivery in both English and Chinese. Students were informed that they should complete them once they had finished their course of study. This was entirely voluntary. For example the survey from the French and German course was only completed by 20 of the 150 students. This was despite the fact that the bespoke Moodle spaces were regularly used by students in class and enhanced by being actively demonstrated by the teacher. The survey results show that 65% of students indicated that they used the PLE, while 20% stated that they did not use it, with the remaining 15% reporting that they did not know what was meant by the term PLE. Similarly it was also noted that students felt that their knowledge of e-learning was quite good (65%); with the remaining 35% recording their knowledge as high and better.

Students reported an overall positive experience of using the PLE. Using a Likert-type rating scale with a range from 1 (strongly disagree) to 5 (strongly agree) all but two students either agreed or strongly agreed with the specified statements, such as “I find a PLE useful for my work,” “I accomplish my work more effectively with a PLE,” “I find the exercises provided in the PLE helpful for my learning,” “It is easy for me to use a PLE,” “It is easy for me to use a PLE,” and so on (see Appendix x for the detailed results of this PUEU survey). Interestingly, the two negatively formulated questions, namely “I find using a PLE frustrating” and “I find interacting with a PLE requires a lot of my mental effort” received less positive answers, namely 7 students agreed or strongly agreed, and 13 students were neutral or disagreed.

Several questions in the PUEU survey inquired whether students would like to modify their PLE by adding new widgets or by replacing widgets. The majority of students (15 or more) agreed with this premise. Furthermore, the perceived value of specific widgets was also investigated. They remarked that they thought that the preassembled PLE/Moodle space was well designed. This manifested as very positive ratings for all widgets. The actual Moodle usage logs, however, indicate that only a few ROLE widgets were actually used by the students (mainly the translation tool and some of the exercises), although the teacher encouraged usage in every class. The results from the survey, therefore, can be seen as representative of potential interest rather than reflecting active ROLE widget usage.

Significantly the English students completed fewer surveys than those on other courses, and correspondingly their rating was also less positive. In the English courses it appears that the focus was on the exercises and, in contrast to the German/French courses, where the English teacher used the PLE/Moodle spaces less frequently in class. The survey also revealed that the majority of English students did “not know what was meant by PLE” (more than half of the given answers). Those English students who declared an understanding of the term PLE also rated the perceived usefulness and ease of use positively albeit less than those students in the German/French courses. It also appears that the English students also are less inclined to assemble or change widget spaces (as evidenced by the answers to the respective questions). In addition, the responses relating to the perceived value of the provided tools appear to be mostly average, with only the translator and exercises being rated slightly more positive.

Results from the Activity Recommender and To-Learn task list: In addition SJTU also conducted a further evaluation of two specific widgets, namely the To-Learn list and the Activity Recommender, within the Business English class. The To-Learn list enabled students to define and work on to-do-lists specific for learning. The Activity Recommender supported students in preparing a presentation, and can add tasks to the To-Learn list if the student agrees. For this evaluation, the students were given the mandatory homework of preparing a set of slides for a product presentation and also needed to use a PLE space that contained the two widgets. Due to the usage of the widgets, and the completion of the survey being mandatory, a large number of students (240) completed the survey.

Initially a preliminary evaluation took place a few months before the deployment of the second survey evaluating the usage of the implemented ROLE tools. In this first evaluation, the activity recommender was implemented as a mock-up using slides to introduce the widget. The immediate student feedback and a recording of the class' reaction to the idea of this widget served to inform the ROLE partners of some potential shortcomings. The second evaluation, using the implemented tools, took place over a period of 4 weeks. The students received the (previously described) task to author a set of slides that portray a real or imagined product that a company would sell. The task was mandatory as homework. Students were also instructed to use the two ROLE tools during the authoring of their homework.

The evaluation revealed several problems: those related to technology, e.g., features did not run due to browser issues and related to task/tool understanding, e.g., students did not understand the purpose of the tools. Thus, while the overall number of participation of the student was very high (given that this was a mandatory homework), the dissatisfaction of the teacher and students (as conveyed orally and by email) was also high, resulting in the suggestion that the tools needed to be improved for more effective usage in a classroom environment.

The quantitative and qualitative outcomes arising from this evaluation are based on survey results with a sample size of $N = 239$. It can also be reported that the answers to the free text question "Did you have any problems using the Activity Recommender and the To-Learn-List?" revealed a series of technical issues as well as disclosing a lack of understanding among the student group that manifested as significant usability problems for them. That may have been influenced by the fact that SRL was a concept these learners were not used to. Since the level of English of the learners was relatively high, the problems were not primarily caused by comprehension problems. It is important, however, to take into account that the Learning Activity Recommender widget that they were using was designed originally for a specific group of learners who would have needed substantial support and guidance related to their cognitive level and, therefore, was not designed with all learners in mind. Nonetheless the overall survey results can be interpreted as quite positive with regard to the perceived usefulness of the ROLE widget bundle. Since the To-Learn List in the evaluated widget bundle offered support for learners with good meta-cognitive competences it could be used a convenient tool.

Widget Authoring Tool and teacher interviews: One of the major problems regarding the usage of ROLE technology at SJTU is that most teachers do not appear to be interested in many of them as they feel that there are too few appropriate widgets available that they can use in their courses. To overcome this problem, the ROLE staff at SJTU developed an easy to use authoring tool that requires little technical knowledge. In order that the authoring tool fulfills the teachers' expectations and also meets the ease of use requirement, separate interviews with five teachers were arranged in which a mock-up of the tool was presented to the teachers. During the interview, the mock-up was used to go through the authoring process. This helped to identify any immediate difficulties and enabled the immediate collection of suggestions from the teachers. The tool has now been made available at SJTU. It uses ROLE technology such as inter-widget communication to capture interaction data and to allow students to rate widgets.

The SJTU teachers involved in the courses using the ROLE technology were invited for a semi-structured interview with the aim to record their experiences with ROLE and how they would like to see ROLE improve in the final year. Two of the teachers accepted to be interviewed online and a third teacher accepted to provide a paper-based response to the interview questions. Overall the respondents thought that ROLE was extremely useful as it made possible to allow learners to access materials in a more flexible manner, enable them to self-assess their skills, enable them and teachers to have enhanced access to course metadata.

All of the respondents expressed that they will continue to use ROLE tools in future because they were impressed by the benefits it brought to their learners (e.g., access to greater and better resources) and to them (e.g., monitoring, portability, etc.). The respondents zeroed on in two areas of improvement, which they mentioned throughout the interview. Firstly the need to demonstrate the value of developing more contextual or subject specific widgets and bundles:

> I think what we have to do is to show more clearly the value that ROLE can bring to the teacher, so I think the basic technology is there. But it's not every visible in the current widgets, the current tools that are available. I think this is one place where it really needs to improve.
>
> Maybe the developers should understand the course, because different courses need different learning pedagogies. The theory and experiment methods for different course are depended.

Secondly, to make the widgets and associated technologies facing the end-users much easier to use without the need for any more technical knowledge than using Facebook for example.

> . . . . but maybe just something like Facebook, where I can just upload, share something, and press some simple buttons. And I think it's still too complicated for me, and also for my students, as I described before. I'm getting a lot of questions. So I think the usability definitely needs to be improved.

Conclusions

Lessons Learned

Two major lessons have been learned by the evaluations at the SOCE test bed. First, the significant role of guidance in such an HE setting, and second, the importance of having a sufficient amount of widgets.

The first lesson became quickly obvious after the initial evaluations based on the Liferay system (cf. Ullrich et al. 2010). The initial approach of PLE usage consisted of introducing the PLE during class on the basis of an example. Then, the students received a homework that required them to use the PLE as demonstrated. For instance, the teacher showed how to record a video using a Web 2.0 service, and the students' homework consisted of recording a video, without a given specific topic. This open approach was motivated by the thought that the more open the task was, the more motivated the students would feel. However, this initial approach failed. None of students did this or any other similar open homework, interestingly although the students rated the PU of the PLE very high. In the next iteration when given more guidance by the teacher with specific tasks to perform the number of handed-in homework increased. We believe the low initial uptake despite PU is due to several reasons. First, students quickly become overtaxed. The concept of a PLE is unfamiliar, the embedded services are new to them, and they have only limited experience in Web 2.0 in general. Second, students often do not see the value in learning how to use these tools. They feel it distracts from learning grammar and vocabulary, and does not prepare them for the exam. Thirdly, most of the students (and teachers as well) are not intrinsically motivated to use Web services, and the majority of our students feel that the time could be spent more effectively. Thus, the task of the teacher becomes to demonstrate and highlight the advantages of a PLE, and guide them through it, so that the students can arrive at an understanding of what a PLE offers.

Secondly, uptake of ROLE was significantly hindered since only few domain-specific widgets were available. In the case of SJTU, teachers were less interested in general purpose widgets, but asked for widgets covering very specific domain knowledge. Content available in existing Learning Object Repositories was not used in a single case, since these resources were too different from the specific needs of the teachers. For instance, existing learning objects about French were too much dependent of the original course book, and not usable in the SJTU courses due to too different vocabulary. Yet, teachers did find usable resources on Websites not available in learning object repositories. We therefore had to enable teachers of turning these Web resources into widgets usable in their PLEs by using a widget authoring tool. In addition ROLE staff at SJTU offer those courses that use the ROLE technology extensive support by technical teams who can set up the widget spaces and create widgets for those teachers who wish to avail of this service. We could observe that only those teachers who were extensively reported actually used ROLE technology.

Finally, it is important to note that the discrepancy between the often very positive ratings given in the PUEU surveys and the often negative vocal feedback or confusion observed in classes related to ROLE technology, as well as the recorded low actual usage visible in the logs, indicate that, at least in a Chinese context at SJTU, the ensuing survey results should be interpreted with caution. Notwithstanding this word of caution, however, SJTU is still convinced that ROLE technology can enable the easy creation and usage of interactive activities that make the overall classroom activities more interesting and, therefore, empower teachers to offer extra learning activities that go beyond what a standard Moodle online course can offer.

Outlook

SOCE will continue using ROLE technology after the official ROLE project has ended. The teachers who were using PLEs in their classes during the project's runtime have taken over their PLE spaces into the course Moodle sites of the new semesters. Also, new teachers have expressed their interest in creating their own widgets during the presentations of the authoring tool. One teacher from the Social Science department created widgets of Web games about different political topics.

Uppsala University: ROLE for Distance Students Working Collaboratively in Small Groups

The Uppsala University test bed was performed within the distance course "Social software and Web 2.0" at Uppsala University. The course was given during the summer semester in June and July 2011 with 34 students and in the spring of 2012 with around 20 students. The course corresponds to 5 weeks of full-time study. A university wide LMS installation was used throughout the course for the main interaction with the students. The course consists of four assignments each containing a part to be done individually and a part to be done within a group.

Learning Scenario

The test bed involved one of the four assignments in the course. The assignment in question aimed to give the students a deeper look into how social interactions are used in a professional manner, most specifically by a corporation that communicates with its customers via twitter. The students were tasked with finding patterns of behavior and how the social interactions work in a specific medium (in this case micro-blogging and customer relations).

The goal of the assignment, as stated by the teacher of the course, was to use a typology presented by Shaw et al. (2011) to categorize tweets (i.e., 140-character statements made in the social media platform Twitter) sent to and from the Swedish train company SJ during the winter of 2010/2011. This particular winter was unusually problematic for Swedish train traffic, with extreme weather conditions resulting in severe delays all over the country. The assignment thus meant to analyze twitter discussions about traffic disruptions, mainly in commuting. Outside of the study, the students were required to read a paper coauthored by the teacher (Larsson et al. 2011) where a more summarizing typology was used to categorize the same tweets. The students were divided into six groups of 3–5 for the whole duration of the course, and were told to categorize the tweets collaboratively within these groups.

The Personal Learning Environment

The assignment was carried out with the ROLE Uppsala prototype (a slight adaptation of the ROLE SDK with single sign on for the students), mainly using a widget bundle that was developed specifically for the assignment. The bundle resulted from discussions with the course's teacher about what tools he would find desirable for the assignment.

Technical realization: The Analyze Tweets bundle[9] allows students to take a closer look at Twitter tweets. Figure 8 shows the bundle's five widgets. First, tweets and tweet conversations are presented in a timeline. Second, the same tweets are presented in a list and can be tagged with 18 different categories. Third, a pie-chart of the amount of tweets tagged with each category is shown. Fourth, the tweets can be discussed in a forum and references inserted to individual tweets within posts as links. This allows students to, at a later time, refocus on the mentioned tweet by clicking on the link in the post (timeline and tweet list will adjust to show the tweet). Finally, any related content can be shown in the content viewer, for example, any links to Web pages mentioned in tweets show up here if clicked upon. This bundle

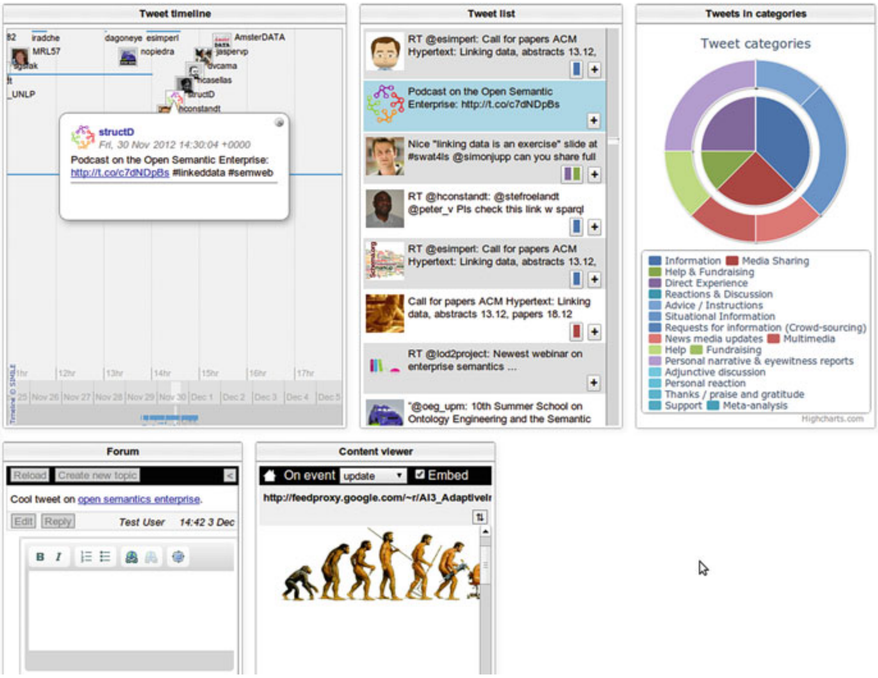

Fig. 8 The analyze tweets bundle

[9] http://www.role-widgetstore.eu/content/analyze-tweets

makes heavy use of inter-widget communications and most interactions performed inside an individual widget have consequences in other widgets.

The bundle is intended to be useful when investigating tweets and the conversations they form. Students can make sense of the various ways people use tweets to communicate by using the provided vocabulary to categorize tweets. The forum allows students to discuss the problems that appear, for instance if some tweets do not fit into any of the provided categories.

The purpose is to give students a chance of experimenting with one way of doing research in the area of social science. A teacher can assess students' performance by looking into the categorizations that the students make as well as their activity in the forum.

Evaluation and Methodology

An initial pre-study was conducted as a survey during the summer course that gave input for the design of the full study in the spring of 2012. One of the results showed the importance of providing a prepared environment rather than relying on the students ability to assemble a suitable environment from scratch. On the positive side was that the students reported that multitasking and having multiple tools on the screen at once was nothing new to them (Jonsson 2012).

Based on the pre-study, and the constraints on what we could do within the given course, a decision was made to test a limited set of functionality provided by ROLE. The choice was to focus on inter-widget communication, and how students perceive a user interface where multiple widgets could be used in combination to reach a predefined goal.

The evaluation method chosen for the test bed was surveys since the context of the evaluation was a distance course at the university, where it was problematic to do interviews or use other methods where the investigator needs to be physically co-located with the users. The survey consisted of 28 questions and was answered by 16 of approximately 20 students taking the course (~80%). The reason for this approximation of the total number of students is due to a discrepancy between the number of students registered for the course and the number actually attending it.

Out of the 28 questions 23 were formulated as statements and the students were asked to position themselves on a 5-grade Likert scale with the polar values labeled as "I fully agree" (1) and "I do not agree at all" (5). As we did not specify intermediate scale steps between the extremes, we can assume an interval scale between these. In order to detect survey artifacts some of the questions were formulated with a mirrored scale. Responses to these were inverted a posteriori to make it easier to interpret averages and correlations between statements. Of the five remaining questions four were free text and one consisted of multiple-choice checkboxes.

For more details about the evaluation, please see the extended report concerning the evaluation of the Uppsala University ROLE prototype by Lind and Laaksoharju (2012).

Results

Most of the students were at some point annoyed with something about the system (AM = 2.25, SD = 1.07). This judgment co-varied negatively with the impression that the system was working flawlessly.

The students did not report any difficulties to learn how the system worked and generally considered the platform to supply good support in solving the assignment (AM = 3.50, SD = 0.82). That widget content was changing automatically when performing different actions in the system was conclusively seen as not confusing (AM = 4.1, SD = 0.93). They also seemed to think that system was relatively easy to work in (AM = 3.19, SD = 0.75). However, there is a tendency to judge the number of required mouse clicks to be too high (AM = 2.44, SD = 1.32).

Students' overview of their working process was perceived as good with an average of 3.5 and a standard deviation of 1.0. The fairly high standard deviation stems from responses being spread over the whole scale; though the majority (12 respondents) settled for a grading of 3 or 4, as reflected by the average value above and by the median value of 4. Significant correlations were observed between this statement and the level of participation and collaboration, the perception of the system as practical and the system's impact on the motivation to complete the assignment.

The students did not seem to have any significant problems understanding how to use the system for the assignment (AM = 3.75, SD = 0.86). Interestingly, this statement did not have any significant correlation with the other statements in the survey.

The support from the system for doing the assignment was perceived as fairly high (AM = 3.5, SD = 0.82). This statement correlates with 11 of the other statements, making it the second best predictor after the perceived support for collaboration.

Applicability in other areas was generally seen as high (AM = 3.38, SD = 1.03). Significant correlations were found between this statement and the perception of the system as motivating/tiring (inverted), the perceived support for collaboration and the statement that the student would have preferred another tool (inverted).

Perceived support for collaboration received the highest count of correlations with other statements, twelve out of 22, making it a good predictor for overall user perception of system usefulness. The statement itself received an average of 2.75, with a standard deviation of 1.07, which is on the lower half of the scale, though still interpreted as relatively high considering the system is still in a development stage.

The statement that the system was practical to use, received an average of 3.31 with a standard deviation of 0.95. This indicates that the students' perception of the system's practicality was fairly high. This statement is also strongly correlated with the perceived lack of problems in the system, the support for collaboration and the perception that the system increased the student's motivation.

The students felt to a high degree like they were part of a team while working in the system (AM = 3.94, SD = 0.93).

Conclusions

Generally the results of the evaluation were positive. They indicate that the students were quite satisfied with the overall usability of the system and perceived that the system increased their motivation for learning and collaboration.

Many of the students were, however, at some point annoyed with the system. We have seen in other studies that students have a fairly low tolerance to usability problems in systems that they are expected to use in their studies. The perception of the system as a whole may thus be biased toward a more negative impression than what would have been the case if the system setup had been more stable.

An interesting, positive result when it came to the users' perception of one of the unique features in this prototype—that widget content was changing automatically when performing different actions in the system— is that it was conclusively seen as not confusing; thus supporting this novel avenue toward automating internal communication between widgets. Initially there were some concerns that this technologically rather advanced approach would also be perceived as complicated by the users, a fear which proved to be unfounded. However, since the students did not get the opportunity to compose their own, unique set of widgets, we cannot determine whether this acceptance was due to a perception of the system as one united whole or whether the widget performance will be predictable even when users pick and choose widgets at will. Future evaluations should address this question.

The results for how useful the different widgets were for solving the assignment are interesting, especially the low score for the tweet timeline. The ambition with this widget is to visualize patterns of interaction between Twitter users over time. However, either few of the students seem to have had use for this functionality or the interaction with the widget was not satisfactory. When looking at the classification data, almost half of the total classifications regard reactions and discussions, for which the widget should be a useful tool. The conclusion to draw from this is that the widget functionality was not apparent to the students, which can be due to either interaction problems or learning problems.

The best predictor for the perceived value of the platform was how well it supported collaboration. This means that students who considered the platform to support collaboration also considered it to be valuable and vice versa. The conclusion we draw from this is that the collaborative aspects of the tool were something that the students expected, and either perceived as present or not. This suggests that the system was perceived primarily as a tool to support collaboration in the solving of an assignment. The fulfillment of the perceived purpose of a tool determines its value assessment. This is also a good result for the prototype as it shows that the students who thought the system was a good platform for collaboration also thought that the system would be useful in the context of other courses.

A perceived good overview seems to be very important for the overall impression of the system as it correlated with other important features, viz., the level of participation and collaboration and the system's impact on the motivation to complete the assignment.

Generally the students felt highly engaged in the team effort of solving their assignment. It is not a controversial claim that a good overview in the system also positively affects the perceived presence of team members. Thus, if an important goal for the system is to stress the value in collaboration, creating a sense of good overview should be highly prioritized.

Lessons Learned and Outlook

The evaluation resulted in the following recommendations:

1. Investigate why some participants perceived the platform as good for supporting collaboration and others not, as this appears to be an important determinant of the general impression of the platform.
2. Keep the number of required interactions (like mouse clicks) at a minimal level. This can be achieved by exploiting the widget communication even more. The participants in the study did not have trouble understanding the automated behavior of widgets even though it conceptually appears rather complex.
3. Reevaluate the platform in a course where it is possible to fully implement the SRL pedagogy. Currently we do not know how users of the system would cope if they were required to choose widgets by themselves. In the current study, the students might not be aware of the intricate, self-establishing nature of the widget communication and it is necessary to find out how this will be perceived when users set up the learning space by themselves.
4. To address how complete SRL platforms are for students, future evaluation surveys should include questions about whether any other means of contacting group members were used in parallel, e.g., instant messaging (like MSN Messenger, Facebook chat), conference call (like Skype), collaborative documents (e.g., Google Drive). The aim should not be to create tools to replace existing, well-functioning communication solutions but to complement these.

On the whole the results of the evaluation were encouraging and showed that continued work on the ROLE SDK and platform was motivated.

Widget Bundles for Formal Learning: Lessons Learned

In this chapter, we described usage of ROLE technology in three different settings for formal learning in higher education. Despite the differences in the three test beds, the simple fact that ROLE technology was used to support teaching and learning at each of the locations supports the claim of flexibility made by the ROLE project. RWTH and SOCE were able to apply ROLE technology rather extensively and from early on during the ROLE project, and their evaluation results had significant influence on the later course of the project. The UU test bed took place at a later stage in the project and was therefore able to use a prototype very nearly resembling the project's end product.

The evaluation work done at these three test beds has taught the ROLE consortium valuable lessons that shaped the further work:

- The added value of ROLE has to be clearly visible to its users. What became apparent in the two test beds SOCE and RWTH is that technology may not be attractive in itself, but its added value needs to be clearly visible to the users. This was voiced by users in the SJTU test bed, who have a full-time job, limited time available for study and low digital literacy, but also found in the RWTH test bed, which involves students with high digital literacy (similarly, evaluation outcomes from the BILD test bed pointed to the need for communicating the benefits of the ROLE project to organizations).
- The value of ROLE that needs to be made visible includes technological solutions, but also psycho-pedagogical results, i.e., the benefits of SRL, group work, etc. These results and solutions have to be explained in a way the average user (organization, student and teacher) understands.
- Uptake of ROLE technology significantly depends on the availability of widgets. If too few widgets are available for immediate use, then only few teachers will employ such technology. Having a few general purpose widgets, such as widgets teaching SRL or enabling discussions, is insufficient to attract users, instead they ask for very domain-specific resources. Such demand can be fulfilled by offering authoring tools.
- Finally, the primary users of PLEs in formal learning in higher education in the three test beds described in this chapter were teachers, not students. In these settings, teachers used ROLE technology to integrate tools into the daily teaching that enabled additional learning activities. In such a setting, teachers served as multipliers, who demonstrate the potential of personal learning environments to their learners. For instance, the SOCE French teacher reported that having worked with the PLE during the semester for doing homework, his students asked whether and how they could access the PLE even after the lecture was over. They said they found it so useful; they want to continue using it.

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Case Study 2: Designing PLE for Higher Education

Denis Gillet and Na Li

Abstract In this chapter, the concept of Personal Learning Environment is first refined taken into account recent advances and the experience gathered in a European research project dedicated to responsive open learning environments. A prototypal implementation of a Web 2.0 platform enabling the construction, the sharing, and the repurposing of personal learning environments is then introduced. Participatory design and validation activities carried out in the framework of higher education test beds aiming at understanding the benefits of personal learning environments in academic institutions are presented. Finally, the broaden application framework for the deployment and the adoption of open user-centric environments for learning and knowledge management is tackled with perspectives in terms of supporting inquiry learning at school with online laboratories, implementing connectivist massive open online courses or enabling agile information systems for nongovernmental organizations.

Keywords Personal Learning Environment (PLE) • Informal learning • Higher education • Social Learning • Web 2.0

Introduction

Trends

Higher education is transforming under both top-down and bottom-up pressure. On one hand, national policies and international practices are pushing higher education institutions to reinforce their branding to attract more students to prime the researchers pump and to trigger more citations to boost rankings. On the other hand, students currently enrolled in higher education study programs are born with the Internet and have grown as teenagers with ubiquitous access to online resources (free or considered as such), peers, and communities, thanks to flagship search engines and social media platforms. A previous study (Vassileva 2008) has pointed

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out that, today's teenagers are used to learn in context, in response to a perceived demand, or to solve a particular problem. They search the Internet to find articles, videos, or any related materials, as well as scouting through their social networks to find a person who may be able to help. These learning experiences are mostly "solution-driven," rather than "learning on principle."

As a consequence, the school- and course-centric *closed* learning management systems (LMS) do not fulfill and match anymore the institutions and students' expectations and practices. They do not provide the necessary international visibility for the institutions to be recognized as excellence teaching centers and they do not provide students with the *open* and persistent free access to resources and peers they are used to. The activity- and student-centric model of personal *learning* environments (PLE) better supports the opportunistic and agile scheme required by students to interact with resources, experts, and peers for both social and educational purposes. The LMS rather enforce the old *teaching* model focusing mainly on top-down content delivery through lectures, slides, course notes, and fully packed exercise sessions.

The current trend is to equip institutions, teachers, and students with skills and technologies to combine *local* institutional resources with global *open* content from the cloud, as well as to rely on internal and external support provided by peers or experts.

Students have always exploited resources from libraries and relied on peer interaction for learning outside the *formal* institutional settings and activities. However, with the current ubiquitous access to information and communication technologies, such *informal* learning activities and modalities are taking a more important place in the higher education landscape (Gillet 2010).

Activities carried out in the ROLE[1] project have contributed to investigate a pedagogical framework to strengthen self-directed and informal learning, as well as a technical framework to benefit from Web 2.0 PLE. One should also highlight that in the informal setting considered in this chapter, the boundary between learning and knowledge management (KM) is disappearing (Fig. 1).

In the next paragraphs, we provide insights on the current definition of PLE and discuss alternative design and implementation approaches. Then, in section "Dedicated PLE Platform," we present the social media platform designed in the PALETTE (El Helou et al. 2009) and the ROLE (Gillet et al. 2010) projects to enable interaction in online learning communities and agile construction and exploitation of PLE by teachers and students. In section "Higher Education Test beds," test beds set to validate the benefits of such platforms in higher education are presented together with evaluation results. In the ROLE project, these test beds also played an important role for the participatory design and the social requirement engineering processes. Finally, in section "Conclusions and Perspectives," conclusions are drawn and perspectives are provided in terms of supporting inquiry learning at school with online laboratories, implementing

[1] http://www.role-project.eu

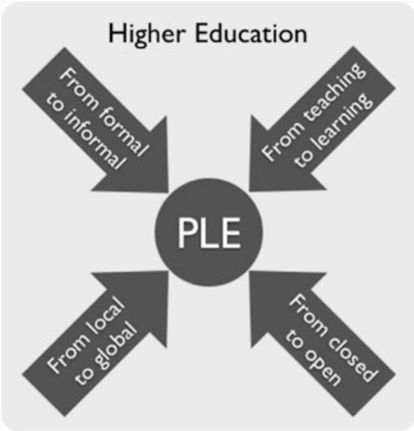

Fig. 1 Trends supporting the emergence of personal learning environments in higher education

connectivist massive open online courses (cMOOCs) or enabling agile information systems for nongovernmental organizations (NGO).

Definition of a PLE

The concept of PLE is not new. According to Wikipedia,[2] it was first coined in the 1970s. It was however rediscovered and consolidated with the emergence of the social Web (Web 2.0) that enabled users to take control of their online resources and interact freely with peers worldwide. Nowadays, conferences series such as the PLE Conference[3] are fully dedicated to discuss issues and investigations related to PLE.

Initially, definitions of PLE were enforcing the combination of the online and physical resources to define the learning settings. As example, both the computer applications and the physical books the students may use on a desk at home to carry out a given activity can be considered as part of the corresponding personal learning environment. The same could be said for peers sitting around a table in a cafeteria and discussing or completing homework assignments. However, physical modalities and the associated offline actions are difficult to identify and to track within supporting online platforms; the tendency is then to ignore them or to consider them as embodied in the user model. Other definitions were mainly focusing on the concept of mashup of Web applications (apps), which happened to be too restrictive (Wild et al. 2008).

The current conceptualization of a PLE is rather corresponding to an opportunistic aggregation of online content, information, services, and people for a given

[2] http://en.wikipedia.org/wiki/History_of_personal_learning_environments

[3] http://pleconf.org

Fig. 2 The PLE as an aggregation of information, content, services, and people

activity. The variety of physical interfaces enabling the access and the interaction with the mentioned entities is also evolving and is currently integrating not only desktop and laptop computers, but also mobile devices such as smart phones and tablets. Data gathered or published by online smart devices can also be considered as resources or channels. As a consequence, we can define a *PLE* as (Fig. 2) (Gillet 2013)

> a shared online opportunistic and possibly ephemeral aggregation of communication channels, cloud resources, Web applications, and communities or peers (directly or through social media memberships), assembled in an agile way to define an interaction context for a given learning or knowledge management purpose, and accessed through interactive devices (computers, tablets, smart phones, . . .).

In this definition, communication channels correspond to live discussion streams or notifications usually made of short text messages or links. Content is referring to multimedia resources that exhibit some persistence. Loosely-coupled distributed services and online tools are accessed using Web applications.

It is important to enforce that any digital ecosystem can be considered as a PLE if it has been repurposed for learning and knowledge management. It is more the intention of use than the design itself that defines the nature of the environment (Charlier et al. 2010). Obviously, the construction of the environment is part of the learning activities and is an important ingredient in the appropriation of the resources and the motivation to carry out the corresponding learning activity. As such, the PLE realm pushes further constructivism, by not only enforcing the definition of personal activities and resources by learners, but also by shaping the related interaction environments. As embedded in the PLE term, such environments are personal. They are however not individual as most of the time interaction with peers or experts is desired and supported. Finally, one should underline that each learning or knowledge management activity carried out by a user may rely on different tools and resources, and, as such may require the construction of a different PLE. This is the reason why PLE are often ephemeral, i.e., they may be abandoned once the activity is completed. It is also why their construction should be agile, i.e., they should be shaped to each context and purpose.

The above definition clearly shows the importance of the agile construction of the PLE by the users themselves. Such a construction requires quite high IT literacy and self-directed learning skills. The higher education framework is hence an interesting setting for validation of the PLE paradigm, as the acquisition of autonomy is one of the main educational objective and outcome. Section "Conclusions and Perspectives" will especially show that students and early-stage researchers enrolled in graduate studies programs form an interesting community to elicit PLE requirements and evaluate PLE benefits.

The ROLE project attempted to provide guidance for the design of self-directed activities and environments to students without the necessary level of autonomy, but had troubles to provide evidence that IT tools could help students with limited IT literacy to build IT environments on their own. For more autonomous students, the definition of personal learning objectives and the selection of the corresponding resources and services appeared to be generally carried out implicitly, requiring as such no specific technical support.

Alternative Design and Implementation of PLE Platforms

If one would stick on the PLE definition proposed in the previous paragraph, there should be neither design nor implementation of platforms enabling the construction of PLE. Any set of communication channels, cloud resources, Web apps, and people assembled by a user would become a PLE. As a matter of fact, most of the students in higher education build their own learning environments without identifying them as a PLE and even without noticing that they are actually building learning environments. A simple set of URLs, a *LinkedIn*[4] or a *WhatsApp*[5] group dedicated to a given topic studied could be considered as a PLE.

As the concept of a free ecosystem assembled by a user fits very well with the definition of PLE, it makes it difficult to induce changes in the way higher education institutions shared and exploit knowledge and support students in both their formal and informal learning activities. It also makes difficult the development of IT literacy and autonomy for bachelor students in the usage of the social media platforms and channels for educational purposes. Social media platforms and channels are mainly considered as social interaction and entertainment tools. Last but not least, the current digital ecosystem solutions do not facilitate the storage, the sharing, and the repurposing of personal aggregations related to the study of given topics or the completion of specific activities. As a consequence, teachers and students have the tendency to continuously reinvent the wheel in putting together their learning environments.

[4] https://www.linkedin.com

[5] http://www.whatsapp.com

Following the above comments, it is still beneficial to adapt current LMS to enable a more flexible exploitation and enrichment of the learning resources and contexts by the students, as well as to provide alternative platforms to enable the construction and the sharing of PLE by the users for the users. The next section describes the Web 2.0 PLE platform designed and developed in the framework of successive technology enhanced learning research projects, especially in ROLE, to support the construction of PLE, their sharing and their repurposing.

Dedicated PLE Platform

Design Objectives and Models

As stated before, a PLE is an aggregation of dedicated channels, resources, apps, and people by a user, i.e., typically a teacher or a learner, for a specific learning or knowledge management purpose. So, any platform supporting the construction of PLE should support the *aggregation* of the mentioned entities and their *hosting*. For the sake of symmetry in the way we treat the various entities being part of a PLE, we talk about the aggregation of people, which in fact means the ability of *sharing* the PLE with peers or experts and the possibility of *repurposing* it for their own or collaborative usage. When dealing with entities gathered from the cloud, due to their plethora, *search* and *recommendation* features are required. Finally, in an open framework where users may prefer different platforms to exploit their own PLE or the ones shared by others, *import* and *export* features in open Web standards are important (Fig. 3).

The concept of PLE being abstract, for design and implementation purpose it should be materialized as an online context dedicated to support a selected individual or shared activity. As a consequence, we coined the concept of online *spaces* as

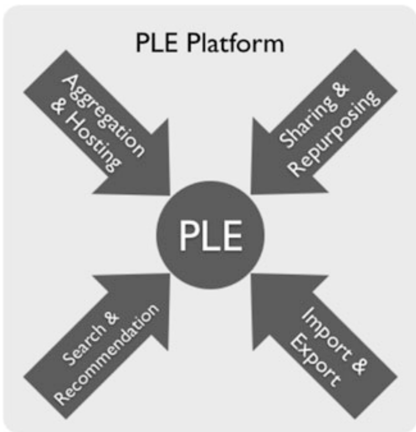

Fig. 3 Required features for PLE platforms enabling the agile construction and exploitation of personal learning environments

the personal online places in which communication channels, cloud resources, Web apps and people are aggregated to support specific individual or shared activities.

This space concept has first been introduced in Gillet et al. (2008), then formalized in El Helou et al. (2010) as the 3A model, and finally standardized in Bogdanov et al. (2011) as an *OpenSocial*[6] space specification. Hence, in the rest of this chapter, the notion of PLE, space and learning context are considered as equivalent. Obviously, a particular case of a share activity is an individual activity and a specific case of cloud resource is an internal resource (belonging to an institutional or an enterprise cloud).

The agile creation by aggregation and the repurposing of a PLE being by essence a user-centric self-directed activity, the user should be able to set easily privacy settings and to assign specific roles and rights to the various people he or she is sharing the PLE with, i.e., the people he or she is carrying out the activity with. Such people are considered as the members of the shared online space. The lack of a fine control in the privacy settings and in the selection of people for specific activities is one of the reasons why LMS and flagship social media platforms are not very convenient to support the creation of PLE. The other reason seems that users do not want to mix their social and professional or educational networks online, and do not perceive a connection between their online activities and learning in classrooms (Greenhow and Robelia 2009).

The notion of open educational resources (OER) is embedded and even extended in PLE. In effect, in addition to promoting the sharing of resources like multimedia documents, in the PLE framework we promote the sharing of Web apps offering dedicated services only required for specific activities and the sharing of the PLE themselves. In (Gillet and Bogdanov 2013), it is shown how a PLE instantiated as an *OpenSocial* space can be openly or privately shared as a meta-widget. *OpenSocial* apps (widgets, gadgets or meta-widgets) are in fact a combination of xml and *javascripts*. They can be compared to readable digital artifacts and shared using *Creative Commons*[7] licenses. Such licenses are more suitable for the model of applications as a service (AaaS) relying on distributed infrastructures than the old open source licensing schemes working only for software that can be delivered on a memory stick as a standalone package.

Prototypal Implementation

Taking into account the specifications for a PLE platform stated in section "Dedicated PLE Platform," the *Graasp*[8] platform has been designed and implemented following an agile development methodology combined with participatory design

[6] http://opensocial.org

[7] http://creativecommons.org

[8] http://graasp.epfl.ch

and validation in test beds, including the ones described in section "Higher Education Test beds." The elicited requirements could be summarized as the following design objectives for the platform that should:

- Enable the creation of PLE without the intervention of system managers.
- Be free of rigid structures and contexts (such as a course structure with specific types of activities and resources).
- Enable opportunistic and focused activities.
- Enable the aggregation of cloud resources.
- Enable agile management of resources in contexts.
- Enable the fine control of roles and rights in contexts.
- Provide open search and meaningful recommendation of resources, apps, and people.
- Rely on open Web standards similar to the ones used by social media and knowledge management platforms (avoiding carefully any specialized standard like the one dedicated only to learning).

The core *Graasp* feature is to enable the creation and enforce the exploitation of dedicated online spaces as activity contexts (PLE). These spaces are defined, configured, shared, and populated by users, for themselves and for the audience they choose. *Graasp* stands for **g**rasping **r**esources, **a**pps, **a**ctivity **s**paces, and **p**eople. As a matter of fact, any space can embed subspaces supporting subactivities. However, hierarchy is not enforced. Users may decide to create either a flat or a hierarchical space structure to support their various learning or knowledge management activities.

Graasp spaces can include members, resources, subspaces, and apps. In addition, each entity has its own description implemented as a wiki enabling collaborative edition, a dedicated discussion thread, tags, and personal or public ratings, enforcing in such a way contextual exploitation (see Fig. 10 in Chap. 8).

In *Graasp*, there are three audience levels. Spaces can be *public*, i.e., visible to everybody, *closed*, i.e., restricted to their members (but external people can request membership), or *hidden*, i.e., only accessible by invited members. There are also three possible roles for the members of a space. They can be *owner*, which means that they can add or remove resources, as well as invite members or revoke memberships. The owner role can be assigned to more than one member of a space, which is a unique *Graasp* feature that enables to pass responsibilities over when required. People can be *contributors*, which means that that can add resources and can create subspaces for which they have the full control of the participants. Finally, people can be *viewers*, which means they can access but not alter the content of a space. They can however post comments, which is an important part of the asynchronous interaction in shared online activities.

The agile aggregation of cloud resources is supported by an open source plugin architecture and implemented as a *GraaspIt*! bookmarklet which provides a one-click aggregation of external resources in the *Graasp* clipboard for further integration in spaces (see the Chap. 8 for more details).

Higher Education Test Beds

Offering a PLE platform to teachers and students in a higher education setting is a way to provide them with more opportunities and facilities to exploit and repurpose individually or collaboratively learning resources gathered from various sources. For adoption, such platforms should bring a high added value compared to institutional solutions extensively deployed like LMS. If a teacher wishes to share the slides of one lecture with students enrolled in a class, using the institutional LMS is obviously the way to go. However, if the objective is to help the students to develop teamwork skills by completing autonomously a collaborative project involving not only classmates, but also alumni or external experts, a PLE platform is a better and more agile solution.

In this section, two test beds are described. First, the scenario and the evaluation of the exploitation of a PLE platform for teamwork activities as part of a bachelor course on *Human Computer Interaction* offered at Tongji University is presented. The design of social media platforms being part of the syllabus, the advantage of using a PLE platform in this case is twofold. It helps to illustrate the subject matter and it enables an easy management of the self-defined activities and the co-produced assets by the students themselves. Second, the support of inter-institutional training activities on Science 2.0 practices and solutions for doctoral students at the Swiss national level are detailed. Again, the benefits are twofold. The doctoral students discover how social media platforms can support their daily research activities and they also exploit the same platforms to exchange best networking and dissemination practices.

These two cases emphasis the fact that using PLE or social media platforms in higher education is simultaneously a will to help users in developing IT literacy and teamwork skills, as well as a way to empower them in their learning practices.

Teamwork at the Bachelor Level

To examine the acceptability of *Graasp* in terms of supporting teamwork in higher education, it was used as a collaborative platform in the *Human Computer Interaction* course offered at Tongji University in China during two consecutive years, i.e., in 2011 and 2012. Twenty-eight undergraduate students were enrolled in the course during the first year and 26 during the second.

In addition to attending traditional lecture sessions, the students had to complete a collaborative design project using *Graasp* as a support platform. Both years, eight participatory design teams of 3–4 students were freely formed. The students spent about 10 h to design the mockup of a social media application. They also delivered a short report and gave a final presentation to their classmates and experts.

After a short introduction to *Graasp*, students were encouraged to create their project spaces, share resources with each other, play different roles for the participatory design (manager, designer, user, developer), and work with different project-oriented apps (task assignments, mockup edition, ...). A survey was conducted aiming at evaluating the acceptability of the platform in sustaining collaborative learning. Results of the 2011 evaluation have been detailed by Li et al. (2012). The importance of privacy settings for shared spaces was confirmed by the fact that in 2011 50 % of the spaces created were set to public, 47 % closed and 3 % hidden, and in 2012, 60 % were set to public, 32 % closed and 8 % hidden. The students had also to pick five adjectives that closely matched their personal reactions to *Graasp* from a list of positive and negative words (Benedek and Miner 2002). A word cloud, showing the frequency of the selected adjectives is presented in Fig. 4 and Fig. 5 for year 2011 and 2012, respectively. The word clouds show that the personal control, the ubiquitous accessibility and the trust enforcement of the PLE platform are part of the core added value. Results also show that improvements were achieved through participatory design between the two evaluations as efficiency and ease-of-use increased.

Students' answers show that they do not have traditionally support platforms for teamwork, for which they mainly use instant messaging applications (100 % in 2011 and 59 % in 2012) or email (64 % in 2011 and 38 % in 2012) simultaneously or not. The introduction of *Graasp* was hence quite welcome. Students assessed that thanks to this platform they could accomplish their teamwork more effectively and that their motivation increased (only 10 % disagree with these statements). The fact that they can easily share resources with teammates, freely organized them, and seamlessly aggregate content from different sources were the main useful features according to the students (Fig. 6).

This evaluation confirms that PLE platforms are useful for self-directed activities carried out by bachelor students and involving agile resources aggregation, roles assignment as well as right management.

Fig. 4 A word cloud based on frequency of selected adjectives in 2011

Fig. 5 A word cloud based on frequency of selected adjectives in 2012

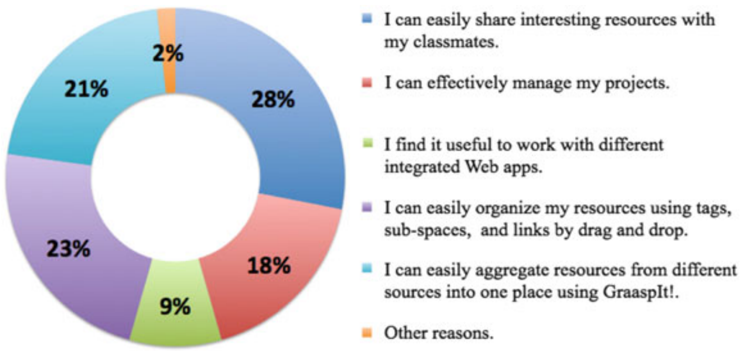

Fig. 6 Usefulness of the *Graasp* platform for teamwork

Science 2.0 Literacy in Doctoral Studies

Despite the fact that more and more European universities are putting together doctoral courses or programs, most of the learning activities for Ph.D. students are self-directed. As a consequence, doctoral students are really eager to develop their skills to conduct research and learn from their peers. Acknowledging this need, the Federation of the French-speaking Swiss universities (CUSO[9]), which is offering inter-institutional continuing education programs, has decided to offer a soft skill workshop series co-organized by the University of Fribourg, the University of Geneva, and the EPFL to doctoral students of any discipline.

Three of these 2-day workshops were organized in 2011 and 2012. The first one held in Geneva was described in (Bogdanov et al. 2012). The second and third one held in Fribourg and in Lausanne, respectively, are discussed here.

[9] http://www.cuso.ch

There were three objectives for the introduction of a PLE platform to support these workshops. First of all, it helped the educators belonging to the organizing institutions to collect and share their presentation material in advance and makes it available to the participants for preparation purpose prior the face-to-face sessions. This is a typical case when an open PLE platform is required as local institutional platforms cannot be used due to access restrictions for external people. Second, the PLE platform was exploited during the sessions by the participants to discuss and share their own resources and to practice their IT skills. Third, the participants were encouraged to continue to interact using the PLE platform after the events as an emerging community of practice.

The main topics covered during the workshops were the search and exploitation of digital resources (especially scientific references), digital intellectual property rights, as well as Science 2.0 practices using PLE platforms and other Web 2.0 tools.

In the part dedicated to PLE, *Graasp* was quickly introduced. A 30-min activity was then organized during which the participants had to build a personal space to collect references and discuss the state-of-the-art of their Ph.D. thesis with peers and with their supervisor. The participants created the spaces they deemed appropriate, invited selected people with the relevant roles, started to populate the spaces with chosen resources, and initiated discussions. This activity gave them the opportunity to discover the features of the *Graasp* PLE platform and experience with the benefits of contextual resource aggregation and discussion for a specific purpose.

The evaluation carried out at the end of the workshops was quite general and covered all the topics and the platforms presented during the 2-day events. One of the clear and obvious findings of the evaluation was that the students were overloaded with new tools. Hence, these tools need to provide a very high added value and have the potential to be exploited for the all duration of their Ph.D. studies for convincing Ph.D. candidates to invest time to master and exploit them. The main added value that was elicited for *Graasp* was its ability to aggregate resources from different sources in dedicated spaces; the resources being either Web bookmarks with previews or online documents. The other features were too numerous for the participants to really discover and benefit from them. Hence, we can conclude that in this case, the PLE platform was more useful for the educators to prepare, collect, and disseminate the teaching material in an agile and effective way, than for the participants. As a matter of fact, this is a general outcome of the ROLE project to highlight that sharing and repurposing of teaching materials among teachers, which are indeed self-directed learners, is an essential need which is effectively fulfilled with PLE platforms.

A side outcome that was expected from this workshop series was that, taking into account that in Switzerland all doctoral candidates also act as teaching assistants, the participants would disseminate their best IT practices and preferred PLE platforms in their teaching activities with undergraduate and master students. Whether this goal was achieved has not been evaluated.

Conclusions and Perspectives

The main purpose of PLE platforms is to bring more flexibility for organizations, teachers, and students in the way they aggregate and exploit online resources and services, while relying on peers and experts outside the formal class settings around which the traditional curricula are still organized. As a consequence, the application of the underlying PLE paradigms goes beyond the cases described in the previous sections. In fact, interesting new application domains have emerged recently and are described below. First of all, the concept of shared spaces integrating applications happens to fulfill to need of inquiry-learning education at school using online labs. This case is described in section "Inquiry Learning Space for STEM Education at School Using Online Labs." As the informal aggregation of resources from various sources and shared with various people is part of the definition of agile knowledge management, large NGOs are becoming interested in the PLE platform paradigm. The NGOs' requirements and how they can contribute to the enrichment of PLE platforms are described in section "Supporting NGOs." Last but not least, the current trend in delivering Massive Open Online Courses (MOOCs) using revamped LMS platforms brings back the old question of finding the right balance between teaching and learning in higher education. While the mainstream MOOCs platforms like *Coursera* or *EdX* emphasis paced video content delivery, the PLE platforms can enable connectivist MOOCs to be implemented by enabling teachers or students to assemble and control the exploitation of openly available learning resources. This case is discussed in section "Supporting Connectivist MOOCs."

Inquiry-Learning Space for STEM Education at School Using Online Labs

The European Commission is funding for 4 years (2012–2016) a large-scale research project called *Go-Lab* aiming at promoting Science, Technology, Engineering, and Mathematics (STEM) education at school using online labs (Gillet et al. 2013). The solutions required to achieve this goal are trifold. First, *Go-Lab* has to strengthen and support communities of STEM teachers. Second, *Go-Lab* has to provide students with inquiry-learning spaces enabling the exploitation of online labs with proper scaffolds. Third, the online labs should be accessible through open Web apps facilitating their aggregation and repurposing by the teachers themselves.

The ability of the PLE platform presented in section "Prototypal Implementation" to support online communities, to create structured spaces, and to aggregate Web apps fully fulfills the *Go-Lab* requirements. In *Go-Lab*, *Graasp* is exploited by teachers to create inquiry-learning spaces in which they can organized all the resources necessary for the students to carry out the five typical phases of inquiry learning, i.e., orientation, conceptualization, investigation, conclusion, and discussion (Fig. 7).

Fig. 7 The Graasp PLE platform exploited by teachers to create, share, and repurpose inquiry-learning spaces dedicated to STEM education (in this case to exploit the Hypatia tool provided by CERN to study to conservation of momentum in collisions of particles)

The lower or higher secondary school students typically carrying out inquiry-learning activities having to concentrate on exploiting the online labs, obviously do not interact with the PLE platform. However, the export feature of *Graasp* enables the creation of a standalone version of the constructed PLE as an independent Web app. The teacher can create this app once the PLE is ready by clicking on the share button. A secret URL that can be shared with the students is then generated. It provides access to a simple Web page in which the inquiry-learning phases are represented by tabs under which the resources (including the labs) selected by the teachers and the instructions given in the embedded spaces' wiki are accessible (Fig. 8).

This example shows how a PLE platform can be exploited by teachers to construct advanced educational resources, which can not only be presented in a simple form to students, but also shared and repurposed by other teachers for their own classroom activities.

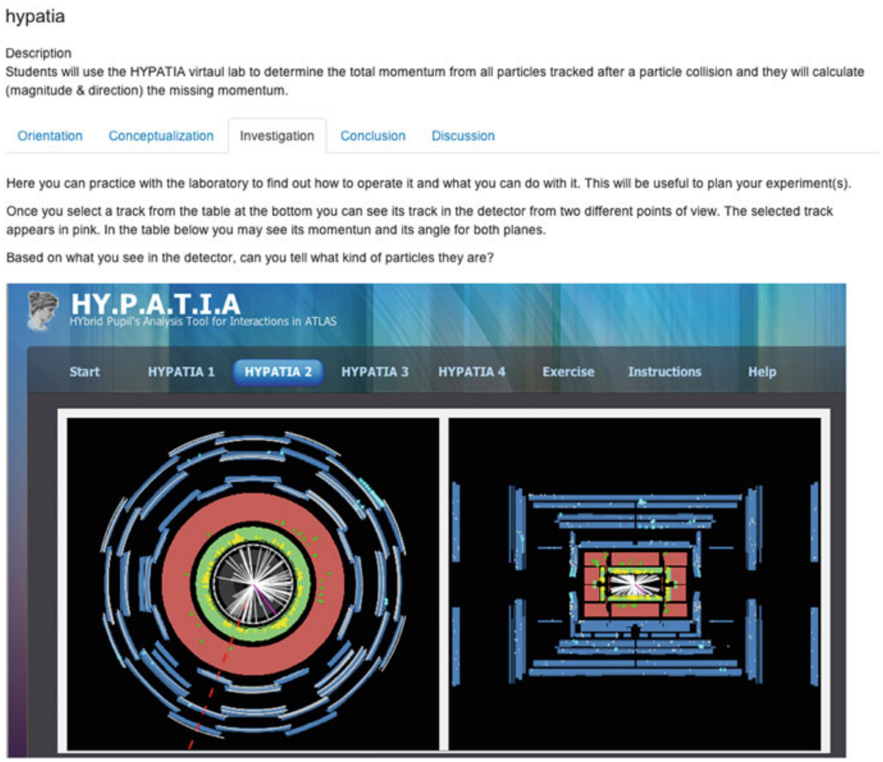

Fig. 8 The simple Web page corresponding to the inquiry-learning space constructed by a teacher (Fig. 7) with embedded Web applications for inquiry learning at school

Supporting NGOs

The PLE and online contextual space features introduced in the previous sections have attracted the interest of global institutions, organizations, and enterprises, and especially nongovernmental organizations (NGOs), not for personal learning, but for agile knowledge management. These knowledge-oriented organizations are operating at a worldwide scale with distributed entities loosely integrated and relying on local hierarchical structures (Gillet and Bogdanov 2013). NGOs have also fast staff turnover and strong digital asset dependency, which require effective knowledge management solutions. The ability to create contextual spaces managed in an easy and agile way by freelance experts in the field or in operation is hence very attractive to such organizations. Their main additional requirements compared to the defined PLE platforms are:

- Being able to integrate aggregation and interaction spaces in matrix structures (a space corresponding to a given project like *Digging a Well in Ouagadougou* should be simultaneously located in a geographical area (Africa as an example), in an activity domain (like water management), and a hierarchical department (like operation).

- Managing access rights by roles, i.e., the owner of a space should be identified as *Project X Leader* rather than *John Smith* (or both) to enable an easy transfer of duties and resources to someone else when required.
- Enabling fine identity management such as fusion of user profiles when people contribute to spaces with various credential (such as a general *gmail* account or social media platform *OpenID*) for consolidation purpose.
- Facilitating changes in access rights, i.e., having no distinction between the intranet and the extranet or the internal and external cloud infrastructures (as an example, when public documents are drafted and then made publically available, such feature eases the diffusion process).
- Guarantying the secrecy of some resources as NGOs are often dealing with content which can be politically sensitive. As a consequence, the physical and geographical location of the cloud resources should be fully defined and controlled.
- Automating tagging of contributed content to ease search and recommendation without diverting contributors from their main tasks.
- Enabling proper licensing schemes (such as *Creative Commons*) for digital content so that public resources can only be used or shared under specific conditions defined by the owner.

Such requirements are also very useful in the context of personal learning in which people often combine digital identities (e.g., when they move from one educational institution to another), where privacy issues are also critical (especially when dealing with young students), and where agile role management makes collaborative learning more effective. This section shows the interplay between personal learning and knowledge management in terms of supporting platforms and elicited requirements. In the future, design and validation between these two domains should be conducted more closely for cross-fertilization.

Supporting Connectivist MOOCs

PLE platforms have recently attracted interest from educators looking for agile solutions to develop connectivist MOOCs (Connectivist MOOCs 2013), referred as cMOOCs. Compare to the mainstream MOOC platforms like *Coursera* or *EdX* which are basically LMS open to external students, PLE platforms offer built-in social media features to boost opportunistic interaction and informal exchanges between students. These platforms can also help teachers and learners to aggregate their own MOOCs from resources freely available in the Cloud under *Creative Commons* licenses.

The possibility to add Web apps in PLE platforms is enabling an easy adaption for their exploitation to support connectivist courses, and especially cMOOCs. Kop et al. (Kop et al. 2011) highlighted that a connectivist course is based on four major types of activities, i.e., *Aggregation*, *Remixing*, *Repurposing*, and *Sharing*, which are the typical actions supported by PLE platforms. What is however missing in PLE platforms compare to MOOC platforms is the support for the formal activities. Especially, features to support coaching and assessment are missing, as well as features to support the timing and the structuring of the activities, including the associated content delivery and task assignment. Such features can easily be added in PLE platforms simply by integrating dedicated Web apps. This possible agile extension of the platforms through apps also enables the implementation of solutions to support a broad range of MOOC models, from the most formal to the fully connectivist ones.

Requirement elicitation for cMOOC support in PLE platforms carry out with members of the RESCIF[10] Network of Excellence in Engineering Sciences of the French-speaking countries have highlighted that the following features are especially required:

- Peer evaluation support.
- Creation of quizzes, collection of the answers and analysis.
- Team building and competence bartering support.
- Formalization of time-based and topic-based structures through spaces (timing and navigation) using tables of content, syllabuses or calendars for navigation and exploration.
- Support of additional metadata through internal tags (automatically identified or inherited from domain ontologies) to ease search and recommendation.
- Customization of the portal spaces hosting cMOOCs with graphical templates enforcing branding or group identity building.
- Management of multilingual resources (Wikipedia model) supporting a given activity to broaden the audience and the sharing opportunities with developing and emerging countries.
- Tagging and subtitling of video sequences.
- Online recording and editing of video sequences.
- Integration of e-textbook standard documents (epub3).

These features can however be provided as specialized Web apps. Once integrated in a space dedicated to a cMOOC, these apps are accessible to all members, can be personalized and can store or retrieve information related and resources belonging to this space.

When relying on a PLE platform, a cMOOC implementation facilitates the co-production and co-exploitation of content between different teachers which can provide only materials directly related to their core expertise and rely on colleagues from other institutions for additional OER. Such an approach implemented using a mainstream platform would require challenging intellectual property right negotiations and bilateral conventions for exploitation. As such, the

[10] http://www.rescif.net/en/rescif

PLE platform not only enables to flip the classrooms (by freeing classroom time for personal interaction), but also to flip the institutions (by redefining the educational mission towards collaborative high-quality content edition and accreditation).

Final Words

PLE as considered in higher education correspond simultaneously to a paradigm change in the ways the information is shared and consumed, as well as a paradigm change in the supporting technical ecosystem. Recognizing and acknowledging the large variety of practices and platforms for both formal and informal activities carried out by teachers and students is already an important institutional change. Providing support in developing the necessary IT literacy of higher education stakeholders and even providing alternative PLE platforms helping them to increase their effectiveness in exploiting knowledge artifacts and exchanging competences are the next level of the ongoing academic revolution. Contributions to support this change have been formalized and illustrated in this chapter.

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Case Study 3: Exploring Open Educational Resources for Informal Learning

Alexander Mikroyannidis and Teresa Connolly

Abstract This chapter explores the potential of informal learning within a Personal Learning Environment (PLE), as well as the identified informal learning cultures that have evolved from the use of Open Educational Resources (OER). A variety of research instruments and strategies have been employed to promote the use of PLEs in this case study and capture a rich variety of feedback from Communities of Practice. In particular, there is a focus on the active use of a PLE and its integration with OER available from the OpenLearn project of the Open University. Additionally, this chapter describes the discovered necessary guidance conditions, emergent contrasting learning contexts and evolving different scenarios in use within the selected Communities of Practice. This research has led to the identification of valuable lessons as well as the documentation of challenges that are faced by those using PLEs in the context of informal learning scenarios.

Keywords Informal learning • Learning culture • Open Educational Resources • Self-Regulated Learning • Personal Learning Environment

Description of Case Study

This case study focuses on the analysis of the informal learning opportunities presented by the Responsive Open Learning Environment (ROLE) project. Essentially, this research contains a series of different informal learning scenarios to examine, each of which will be assessed separately. The premise of informal learning (The Organisation for Economic Co-operation and Development (OECD) 2010) in this chapter relates to learning that has been gained through experience and not necessarily from an organised standpoint i.e. the opposite of formal education where pathways are often prescriptive and delivered from an instructor.

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Additionally the information presented in this chapter relates primarily to the use of, as well as outputs of the OpenLearn project[1]—an Open Educational Resources (OER) repository of the Open University (OU). OpenLearn offers in excess of 12,000 h of self-study materials in a variety of formats. These include study materials repurposed as OER from original OU courses, i.e. initially designed for formal delivery, as well as new bespoke OER created by both OpenLearn academics and other non-OU educators; in other words, further facilitating OER available for informal delivery. As the majority of the study materials presented on the OpenLearn platform are made available using a Creative Commons licence,[2] it has been possible not only to reuse selected information but also to author new OER materials for the ROLE project, which can be freely shared to a worldwide audience.

This chapter sets out to examine how an existing platform designed for global OER delivery, i.e. OpenLearn, can be enhanced with the introduction of Personal Learning Environment (PLE) technologies. It also considers a selection of social aspects of informal learning because this often plays a key role within a community of learners (Lane 2008a). These groups may have similar backgrounds or goals, so that a PLE can be used to support them throughout their informal learning process. With this in mind, it is also important to remember that the wider OU staff community is allied to the OpenLearn repository. Thus access to OpenLearn has enabled further investigations to take place in active Communities of Practice that contain a cross section of Higher Education (HE) staff: academic, academic-related, technician and librarian colleagues.

A number of research instruments were deployed to gather data and information from these groups. This included using a variety of dissemination opportunities ranging from seminars relating to ROLE and the use of PLEs to the development of an interactive eBook describing Self Regulated Learning (SRL), plus presentations and conference publications. Table 1 outlines all the events and activities that were monitored, as well as their location and date.

In this chapter, a selection of these events will be described in full detail. Evaluation activities will also be outlined and the subsequent analysis of the research instruments' information presented in Chap. 3. Since many of the events and activities have overlapping learning contexts and objectives, they are illustrated initially in more general terms in the next section. Representative events will be described in more detail in subsequent sections.

Learning Context and Objectives

The first research instrument used in this case study is the seminar/workshop type of events. In terms of a learning context, these events comprised of an introductory presentation about the ROLE project, followed by the setting of a framework for the

[1] http://www.open.edu/openlearn.

[2] http://creativecommons.org/licenses/by-nc-sa/3.0/.

Table 1 Overview of the events, activities and artifacts that constitute this case study's findings

Case study	Date	Location
1. Events (seminars and workshops)		
JTEL Summer School workshop	May 2011	Crete, Greece
SCORE Seminar	July 2011	Milton Keynes, UK
OU eLC Seminar	January 2012	Milton Keynes, UK
Build a Widget Day	March 2012	Milton Keynes, UK
JTEL Summer School workshop	May 2012	Estoril, Portugal
PLE Conference 2012 workshop	July 2012	Aveiro, Portugal
Dev8eD conference workshop	May 2012	Birmingham, UK
ITCM seminar	July 2012	Milton Keynes, UK
International Workshop on Cloud Education Environments	November 2012	Antigua, Guatemala
2. Activities		
ICALT 2011 paper	July 2011	Athens, USA
Chapter in Collaborative Learning book	March 2012	Hershey, USA
OER World Congress conference	June 2012	Paris, France
ICALT 2012 paper	July 2012	Rome, Italy
PLE Conference 2012 paper	July 2012	Aveiro, Portugal
AACE E-Learning Round Table discussion	October 2012	Montréal, Canada
AACE E-Learning paper	October 2012	Montréal, Canada
3. Artifacts		
ROLE online course	Summer 2011	OpenLearn website: http://tinyurl.com/role-course
ROLE online SRL course	Spring 2012	OpenLearn website: http://tinyurl.com/role-srl-course
ROLE SRL eBook	December 2013	Apple iBook Store: http://bit.ly/self-regulated-learning

subsequent workshop element of the seminar, i.e. the use of widgets inside a PLE for learning purposes. All participants had access to a laptop or tablet computer in order to engage with the provided online learning materials.

The workshop element of the events then allowed participants to be introduced to a hands-on and guided use of a PLE. Participants used one of the two bespoke ROLE online courses, generally sharing the experiences in groups of two or more learners. Initially the presenter gave a short summary of workshop objectives but thereafter the individual groups explored the ROLE online course(s) for themselves, by following the self-study structured learning materials. The presenter(s) remained nearby in the room and circulated amongst the participants, answering questions as required. In the final section of the ROLE online courses, there was an opportunity to evaluate the experience and all participants were, therefore, invited to complete a short questionnaire.

The second type of informal learning activity involved presenting and, therefore, disseminating information directly about the ROLE project at a variety of international conferences. This activity took the form of a presentation followed by a question and answer session. Again, this gave the opportunity for the presenter to illustrate particular aspects of the ROLE project, highlighting individual and relevant PLE elements, as well as enabling them to indicate the existence of the bespoke ROLE online learning courses in the form of self-study interactive OER materials. Attendees were encouraged to visit both ROLE online courses post-event, in order to learn more about the project and to complete the short questionnaire related to their learning experience of using the bespoke OER materials (Mikroyannidis and Connolly 2013b).

Dissemination about the ROLE online courses also took the form of using posters. These were used as a visual medium to promote and signpost relevant information related to both the PLE aspect and also the availability of the structured self-study OER materials. Posters were displayed at a number of international conferences and proved to be popular talking points for those attending the events and, in effect, an unanticipated informal learning opportunity for enquirers. The posters gave a visual representation of the ROLE project and provided an opportunity for individuals to enquire and learn more about PLEs from the ROLE representative(s) who presented the poster. Further promotional materials in the form of bookmarks were also available, enabling visitors to "take away" some tangible and memorable signposts with further details about different aspects of PLEs.

A third learning context for this case study is a group described as "artifacts" that have provided bespoke opportunities for informal learning. This group includes the creation of both ROLE online courses. As indicated previously, these practical courses were often embedded into events that were focused on raising awareness about the PLEs. They were also available online for anyone to study at their own time. A further artifact that provided an innovative informal learning platform has been the adaptation of the ROLE online courses into an eBook. Initially, the content of the first ROLE online course was taken and adapted for presentation as an eBook. As a pioneering development itself the ROLE online course had been through a number of iterations and changes, ultimately being published with somewhat different emphasis in terms of content. Likewise, the ROLE eBook followed a similar pattern of development. Whilst the learning objectives for the eBook remained relatively similar to those in the original ROLE online course, i.e. introductory, the actual learning content of the published ROLE eBook was somewhat different in form. This was because the SRL online course materials were merged with the original ROLE online course content. The resulting interactive eBook thus contained the selected contents from both courses.

In summary, it can be said that the underlying curricula presented in each of the previously described themed informal learning events or activities has been, broadly speaking, very similar: i.e. an introduction to the ROLE project's purpose and, in particular, a focus on the use of OER within a PLE to support informal learning. On occasion, specific topics were presented, as required, to the different

Communities of Practice too. In addition, information relating to any necessary guidance for the associated workshop events was given where relevant. Furthermore, the specific development of the two ROLE online self-study courses also enabled either attending participants, or those directed to the courses at a later date, to study the materials at their own pace and, potentially, at a time or place of their choice. Finally, the repurposing of the online course contents as an eBook has enabled the dissemination of information about PLEs and by using associated OER materials has facilitated it to be widely distributed as well as used in many further, and unanticipated, informal learning contexts.

Setup and Organisation of Learning Activities

As previously described, the range of informal learning events offered by the OU has been divided into three broad dissemination categories: seminar and/or workshop events, conference presentations and thirdly the development of bespoke learning activities that have been tailored to meet the identified learning needs and objectives of particular Communities of Practice. Consequently, the associated setup and organisation of the related learning activities was also often custom-made to meet the needs of an event's anticipated or identified audience. It is reasonable to state, however, that most of the embedded learning activities were developed from an original basic master set and then adapted and/or repurposed for each of the individual contexts thus actively implementing one of the fundamental themes of OER that of reuse (Hilton et al. 2010). The underlying premise of adaptation described here having been to identify an appropriate ROLE widget, then create a structured activity around it and subsequently produce a set of achievable self-study tasks related to the topic.

How that learning activity was embedded into the individual event or into the online environment varied according to a number of factors such as adhering to the adopted pedagogic model of the event; assessing the availability and suitability of technology for the learning activity, e.g. considering the appropriateness of the delivery platform, such as Moodle or the eBook. It was also necessary to reflect upon whether the learning activity could be evaluated at a later date using relevant and appropriate research instruments too. The mediation of the learning activity also had to be well thought out. The basic master set of learning activities had been originally developed for use as self-study materials, thus necessitating the additional "presence" of structured and carefully crafted feedback for the user to read, understand and so allowing learning to take place (Conole et al. 2011). Interestingly, in the many face-to-face events it was possible to offer supplementary feedback and answer participants' queries instantly, as required, thus providing another unanticipated blended form of delivery. Mentors, as such, were not provided for any activities as such but, as previously described, there were several opportunities in the many seminars, workshops, conference presentations as well as alongside poster displays for presenters to give supplementary guidance and provide signposts to further details about the use of PLEs.

Learning Culture

The OER-based informal learning materials that were developed by the OU initially adhered to distance-learning pedagogic principles. This basic premise was later adapted to suit a blended model of delivery according to the circumstances of the individual events. The learning culture as such could, therefore, be described as promoting or adhering to one of self-study further described as attractive to those who have a high level of SRL (Zimmerman 1989). Additionally, in general terms of the types of people taking part in the events it can be reported that the majority of those participating, online as well as face-to-face, were staff from HE institutions, often the OU but not exclusively so. As previously described, participants were drawn from a number of different Communities of Practice, including academics, academic-related-staff, technicians as well as librarian colleagues.

PLE Intervention

The overall PLE intervention in this case study was essentially established from a basis of embedding structured learning activities that used selected ROLE widgets and then delivered them via a web interface. The chosen platform employed to display both online courses was the LabSpace[3] area of OpenLearn, which uses Moodle for the delivery of materials and associated educational technology (McAndrew et al. 2009). The PLE in this illustration, thus, involved a Moodle environment as well as the use of the selected ROLE widgets that were embedded in the online courses, enabling participants to access a whole array of further OER materials in their informal learning context.

Table 2 lists the contents of the two ROLE online courses. The first course introduced the concepts and technologies of the project. It provided a combination of tools and services that enable learners to build their own PLE based on their needs and preferences. It also established a course template that was subsequently reused for the development of the second online course focusing on SRL. The template was based on an original OpenLearn study unit format that had been established in the LabSpace area of the website (Lane 2008b). Associated structured learning activities, using widgets, encouraged participants to explore and discover further OER materials or tools to enhance their knowledge.

[3] http://labspace.open.ac.uk/.

Table 2 The ROLE and SRL online course tables of contents

A. The ROLE online course	B. The SRL online course
1.0 Introduction	1.0 Introduction
1.1 Overview	1.1 Overview
1.2 Learning outcomes	1.2 Learning outcomes
1.3 Definitions	1.3 Definitions
1.4 About ROLE	1.4 About ROLE
2. Example ROLE widgets	2. Self-Regulated Learning
2.1 Introduction	2.1 What is Self-Regulated Learning
2.2 Social search widget: Binocs *Activity 1*: Search for OER	2.2 A typical learner: Marcus
2.3 Bibliography search widget: ObjectSpot *Activity 2*: Search for references	2.3 Travel scenario
2.4 Videoconferencing widget: FlashMeeting *Activity 3*: Search for FM replays	2.4 Flora's learning approach
2.5 Collaborative authoring widget: EtherPad *Activity 4*: Use the EtherPad	2.5 Tim's SRL approach
	2.6 Different learning approaches 2.7 ROLE and SRL *Activity 1*: Assess your SRL skills
3. Building a PLE	3. An SRL scenario
3.1 Introduction	3.1 Amanda's SRL journey
3.2 Using Google	3.2 Amanda sets her learning goals
Activity 5: Create a Google account	*Activity 2*: Setting your learning goals
3.3 Adding a ROLE widget to iGoogle	3.3 Amanda looks for learning tools
Activity 6: Add the FM widget to iGoogle	*Activity 3*: Looking for learning tools
3.4 The ROLE widget store	3.4 Amanda uses the learning tools
3.5 The Google gadget directory	3.5 Amanda reflects on the process *Activity 4*: Reflecting on your learning
4. Conclusion and bibliography	4. The PPIM 4.1 PPIM overview *Activity 5*: Using a PPIM tool
Evaluation questionnaire	*Conclusion and bibliography* *Evaluation questionnaire*

The second online course, focusing on SRL, followed a similar pattern in terms of layout. It also has sections, learning outcomes, and embedded activities. Both courses were released under a Creative Commons licence, as indicated earlier, thus enabling their contents to be not only used or studied in situ but also to be “taken away” and, potentially, repurposed elsewhere within the terms of the licence. In other words, whilst the intended purpose of the two courses was to raise awareness about specific aspects of the ROLE project by introducing selected widgets in a PLE to access further OER resources, the design and deployment of the course materials as OER also meant that they could be reused by others too. Again this adheres to a fundamental premise of OER and that materials, tools and technology should be freely shared and accessible to a wide audience (Hilton et al. 2010).

OpenLearn as a PLE

The OpenLearn project has changed significantly since its launch in October 2006 (Lane and Law 2012). It was originally designed as an OER repository, using two websites: LearningSpace and LabSpace. It set out to offer a full range of HE academic subject materials ranging from the arts and history to science and nature, at all study levels from access to postgraduate. Commencing with 900 h of study materials in LearningSpace and 900 h in LabSpace, the now enhanced OpenLearn website currently offers in excess of 1,200 study hours. A number of changes have taken place since the launch, the most notable being the significant increase of available types and styles of study materials. In 2010, the OpenLearn brand also expanded in size and content to incorporate a significant number of both audio and video materials from the former Open2.net website—a platform that had been developed to support joint OU-BBC programmes designed to encourage public engagement with materials related to a variety of HE subjects. It has been reported that there have been 24 million unique visitors and approximately 320,000 registered OpenLearn visitors (Lane et al. 2013).

Through offering the original OER study materials, and then further developing the OpenLearn website to incorporate the Open2.net resources too, the OU has also endeavoured to add value to its Open Content by deploying leading edge Learning Management System (LMS) technologies for learner support. At the same time, using such an approach, it has also actively sought to encourage the creation of informal collaborative learning communities. Alongside these developments, the OU has also pursued the development of international research-based knowledge about modern pedagogies for HE (Sharples et al. 2012). These improvements have also presented the ROLE project with an excellent opportunity to gain access to a wide cross section of learners and educators who engage with OpenLearn OER materials.

The ROLE project has embraced OpenLearn, both in terms of building on its experience of creating OER study materials, as well as enabling access to some of its constituent informal learning communities. By using the LabSpace area of OpenLearn for the development of the two ROLE online courses it has also been possible to not only introduce the idea of a PLE but also offer direct access to selected ROLE widgets that permit end-users to create their own PLE. Whilst materials for the two courses were hosted on OpenLearn as self-study OER units they can, of course as previously indicated, be used in face-to-face settings too. Again, this enhances and improves the possibility of accessing a further variety of audiences that may have an informal learning context. OpenLearn also provided ROLE with the potential access to an unanticipated large global audience.

Evaluation Objectives and Instruments

This case study consisted of a number of events, activities and artifacts that enabled different approaches to be taken to explore the use of OER materials for informal learning. The overall aim of the research was to ascertain how PLEs could be implemented for different groups of educators in the HE sector. The first evaluation objective, therefore, was to determine which of the selected ROLE widgets were appropriate for the different audiences, as well as assess the impact of introducing the idea of PLEs to those who may not have been aware of these technologies. It was important to gauge whether people were receptive to the idea of PLEs in addition to trying to determine if individuals were prepared to adopt any of the widgets in their teaching delivery.

The basic research instrument deployed in the different events was the Perceived Usefulness and Ease of Use (PUEU) Survey, which has been based on the Technology Acceptance Model (TAM) (Venkatesh and Bala 2008; Venkatesh and Davis 2000). The questions in this survey were used in all the test beds of the ROLE project and were tailored thereafter for each event according to the composition of the surveyed groups. Necessary changes to the original survey were, in reality, minimal. The PUEU survey was available online,[4] where all data and information was also collated. It is important to note that each of the ROLE test beds in fact used the PUEU survey thus allowing further analysis across the project to take place. As noted earlier, the PUEU survey was also included as an evaluation opportunity within both of the ROLE online courses. Again it contained the original questions slightly tailored for these informal Communities of Practice.

Where appropriate, additional research instruments were used. For instance, during the workshop elements of an event, the ROLE presenters were able to offer help to individuals or groups as required but in doing so could also observe, first-hand, any pertinent issues that arose. Whilst this was not a systematic collection of data, more so observational and unplanned, it did serve as an excellent opportunity to see how ROLE widgets, in particular, were received, understood and used. Observational notes were recorded. This view of participants' engagement, or not, with a PLE also enabled the presenters to gauge the usability not only of the selected ROLE widgets but also participants' interactivity with the two ROLE online courses. In some respects these observations could be described, therefore, as informal research instruments as previously indicated.

The presenters also could observe any perceived impact that the ROLE widgets had on an individual's informal learning. This was, of course, more difficult to ascertain as an observer but was often reinforced when participants, on occasion, requested help repeatedly thus indicating that they were having difficulty in understanding some aspect of the course. Furthermore, observation could also be employed to ascertain the acceptance of the PLE by different HE groups. Again,

[4] http://fit-bscw.fit.fraunhofer.de/pub/bscw.cgi/39523090.

whilst this was not a systematic collection of data or information, it did serve to supplement the recorded responses in the PUEU surveys.

Methodology, Evaluation and Participants

There are three themes for this case study (see Table 1). Firstly, the seminar and workshop group events. Secondly, the dissemination activities that involved presenting information directly about the ROLE project at a variety of international conferences. Finally, the third group contained a selection of mediating artifacts that provided opportunities for informal learning. Selected examples from each of these three groups will now be described in terms of research methodology.

Event 1: The eLC Seminar
This was an opportunity to introduce the ROLE project to the e-Learning Community (eLC) of the OU and took place in January 2012. The eLC has more than 300 members including those from both academic and related staff in the OU campus as well as potentially comprising of many Associate Lecturers of the OU who are based throughout the 4 Nations and 13 regions in the UK. The eLC offers a regular programme of workshops and seminars to OU staff, also available to invited visitors, and covering a wide range of innovative e-Learning-related educational technology projects.

The ROLE seminar presented an opportunity firstly to describe and then, in the workshop element, encourage the attending 20 eLC members to use the online ROLE courses. As previously mentioned, the self-study units include introductory text about the ROLE project and have various structured activities that enable the learner to use a selection of ROLE widgets. The ROLE widgets that the participants were invited to use are shown in Fig. 1 and are the following:

- *Binocs*: A widget used to search for OER in a number of Web 2.0 repositories, such as YouTube, SlideShare and Wikipedia.
- *ObjectSpot*: A widget employed for bibliographic searching in popular bibliographic indexes, such as DBLP and Google Scholar.
- *EtherPad*: A widget used for synchronous collaborative authoring of a document, where participants shared the OER they found in the other two widgets, as well as their experiences from using the widgets.

By using the online self-study ROLE courses in the workshop, the 20 participants were also able to gain further insights into how to build or adapt a PLE. This was achieved by completing the online courses, which included guided access to the ROLE Widget Store[5] where further relevant, learning and teaching widgets are

[5] http://www.role-widgetstore.eu.

Fig. 1 A selection of ROLE widgets for finding and sharing OER

located. After the initial presentation defining an overview of the ROLE project, its aims and specifically outlining the objective of PLEs, eLC participants were invited to follow the structured activities in the ROLE online courses. During the structured activities, the ROLE presenters moved around the room offering help to participants as required and attempting to aid them with their engagement with the ROLE widgets on request. On the whole, this meant fielding a wide variety of questions, as well as offering constructive advice about how PLEs functioned and where to find out more information relating to this developing area. The ROLE presenters did not actively seek to intervene in the participants learning processes and only responded when requested to do so by individuals. In effect, their presence in the workshop part of the eLC event offered a blended learning opportunity to participants and similarly acted as an informal research instrument to observe participant interactions first-hand.

Event 2: "Build Your Own PLE" Workshop, JTEL Summer School

This event was held in Estoril, Portugal during May 2012. It was established originally by the EU-funded ProLearn project and subsequently supported by the European Association for Technology-Enhanced Learning (EATEL) along with other EU networks of excellence. PhD students in the area of Technology-Enhanced Learning (TEL) from across Europe spend the JTEL Summer School week learning about the latest trends in TEL, and exchanging ideas about their Ph.D. projects.

The "Build your own PLE" workshop was delivered during the JTEL event. Some 14 students attended the session and used a variety of ROLE widgets in order to find learning resources and start building their own PLE according to their research interests. Both the ROLE online courses were used in the workshop.

Other ROLE workshops were also held during the JTEL summer school and these included a coding session using the ROLE SDK (a development service that focused on communication and collaboration), a widget design session, as well as a session concentrating on personalised support for SRL. Thus the "Build your own PLE" event was one of a family of sessions focusing on the ROLE project. Once again, the "Build your own PLE" workshop enabled participants to use the widgets previously described in Event 1.

Event 3: "Build Your ROLE" Workshop, PLE Conference

The third annual PLE conference took place simultaneously in Aveiro, Portugal and Melbourne, Australia in July 2012. Researchers, educators and practitioners in TEL and PLE were brought together for a lively exchange of ideas, practices and visions. A number of ROLE partners, including the OU, delivered a half-day workshop entitled "Build your Responsive Open Learning Environment".[6] Participants were introduced to the ROLE tools and learning methodologies and were encouraged to use these tools in order to build their own Responsive Open Learning Environment. Additionally, they were able to design their desired tools, according to their learning scenarios and requirements, as well as submit the results to a subsequent ROLE widget competition.[7] Once again, there was a focus on the two ROLE online courses within the workshop, along with an opportunity to complete the PUEU survey.

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[6] http://projects.kmi.open.ac.uk/role/pleconf-workshop.

[7] http://www.role-project.eu/WidgetCompetition.

A paper was also presented at the PLE conference, concerning some of the emergent lessons learned from the OpenLearn test bed of the ROLE project. The presenter described the use of widget-based PLEs by informal learners who sought and discovered new OER materials as a result of using the ROLE widgets. The presentation took the form of a "speed-dating" style i.e. not a ubiquitous PowerPoint. A recording of this presentation and the slides were made available after the conference too (Mikroyannidis and Connolly 2012a).

Event 4: The Dev8eD Workshop 2012

Dev8eD is organised by the Developer Community Supporting Innovation (DevSCI), a community of developers in the learning provider sector. Thus the Dev8eD event, held in Birmingham, UK in May 2012, was designed for developers, educational technologists and users working throughout education, who wanted to further the development of tools, widgets, apps and other resources for education.

The ROLE workshop was attended by ten conference delegates. Participants were first introduced to the ROLE project through a brief presentation and then had the chance to use selected ROLE tools during organised group activities. The purpose of these activities was to enable participants to understand how a PLE can be used to support them in their everyday learning and research tasks. Additionally, participants had the opportunity to build their own PLE according to their own learning and research activities.

Event 5: International Workshop on Cloud Education Environments

A workshop was hosted by Galileo University in November 2012 in Antigua, Guatemala. It focused on the exchange of the relevant trends and research results, as well as the presentation of practical experiences gained while developing and testing cloud education environments, both from a teaching and a learning perspective. This workshop raised awareness about both the ROLE project and the function of PLEs in cloud-based environments. Once again, the two ROLE online courses were used initially to attract the new external stakeholders, as well as to underpin this workshop. The workshop was focused on a cloud education environment by examining how such informal OER materials and services can be distributed using a number of different publication channels.

Activity 1: The ROLE Poster and Other Publicity Materials

The Paris OER Declaration was formally adopted during the 2012 World OER Congress held at the UNESCO Headquarters in Paris in June 2012. Over 550 delegates including representatives of governments, educators, NGOs, and international universities attended the Congress, which was organised in full partnership with the Commonwealth of Learning (COL) and supported by the William and Flora Hewlett Foundation (USA).

A poster was displayed in the exhibition area, promoting the two ROLE online courses.[8] The poster gave a visual focal point to which congress participants could

[8] http://news.kmi.open.ac.uk/11/18424.

attend and enquire about the ROLE project. It was an excellent opportunity to promote and disseminate information about ROLE to a wide range of international delegations. This event proved to be an excellent opportunity to promote both the project and PLE developments in a significant OER global gathering. In turn and, as recorded earlier, the poster also acted as a visual mediating artifact that enabled informal learning about the ROLE project to take place.

Activity 2: World Conference on E-Learning Paper

This is an international conference organised by the Association for the Advancement of Computing in Education (AACE) and co-sponsored by the International Journal on E-Learning. It was held in Montréal, Canada, during October 2012. The conference serves as a multidisciplinary forum for the exchange of information on research, development, and applications of all topics related to e-Learning in the corporate, government, healthcare, and HE sectors.

A paper was presented describing a number of the lessons learned as well as the best practices that were observed from the findings of the ROLE OU test bed in summer 2012 (Mikroyannidis and Connolly 2012b). A round table discussion, involving eight people, also took place hosted by the OU. It set out to explore the challenges associated with supporting SRL in HE.

Artifact 1: The ROLE SRL eBook

As previously mentioned, a fundamental aspect of OER is the ability to share and potentially, therefore, try to encourage the reuse of the developed materials (Hilton et al. 2010). It can also be argued that in doing this, it is possible to reach out, disseminate and make contact with new and, possibly, unanticipated audiences. The two ROLE online courses, for example, had been designed with this in mind: reuse and sharing potentially using multiple formats and platforms. The materials that were presented in the LabSpace area of OpenLearn were designed using structured content and XML. This enabled them to be transferable to other platforms as OpenLearn offers numerous export facilities, for example: Moodle backup, SCORM, and IMS package. OpenLearn also allows its structured authoring documents to be used as databases (Hirst 2012).

During 2012–2013, the OU has been exploring as well as taking advantage of new and innovative ways to widen participation in its courses and associated informal learning tools (Connolly 2013; Lane and Law 2012). Whilst there has been a focus on OpenLearn as a vehicle to achieve this, further platforms including Apple's iBook Store and YouTube have also been used as opportunities for informal learning. The advent of the eBook has offered a new opportunity to harness not only existing structured content but also include levels of interactivity previously restricted to the LMS platform (Moodle). As a distance teaching institution, the OU has always endeavoured to extend the boundaries of publishing, as well as take advantage of educational technology to do so. Thus "rethinking" the publication of printed books as eBooks has offered the opportunity to not only alter models of production (i.e. from print to online to mobile) but also to "open out" and extend the fundamental and familiar idea of a book by creating new and exciting experiences for the readers.

With this in mind, the publication of the ROLE SRL eBook (Mikroyannidis et al. 2013) has taken place alongside a growing series of interactive concept publications produced by the OU.[9] It has taken advantage of the HTML5 technology to produce an eBook that can include interactive ROLE widgets and other inline resources. As a consequence, the ROLE eBook provides an introduction to new learning technologies that empower the reader in terms of SRL and by providing access to information about as well as using PLEs. In effect, it is selected content from the previously published two ROLE online courses that makes this interactivity and raised awareness possible. A selection of learning tools has been included that will help an individual to build his/her own PLE and encourages him/her to become a self-regulated learner too. Readers have an opportunity to try these tools through a set of interactive learning activities included in this eBook.

The Evaluation's Participants

As previously mentioned the primary research instrument for the majority of the described events and activities in this case study was the PUEU survey. Essentially, the survey was used to gain an understanding of how participants from different Communities of Practice have attended ROLE events and perceived the usefulness and ease of use for a number of selected and presented ROLE widgets in addition to capturing their experience of using the two ROLE online courses. As indicated earlier, a number of further observational notes have been collected. The latter will only be reported here to verify and support information collected from the PUEU survey.

The objectives for the overall evaluation, therefore, focused on participants' understanding of the concept of PLEs, their use of specific widgets and capturing knowledge of their opinions and interactions with bespoke ROLE products such as the eBook. In this respect, the PUEU survey has proven to be quite useful as it embraced all of these objectives. The survey was easily accessible to all workshop participants and users of the ROLE online courses.

The numbers and profiles of the people who attended each of the OU-led events varied enormously according to location and timing. In summary, it can be reported that the groups ranged in size from 10 to 50. The majority of participants were staff from the HE sector although one group was PhD students. The attendees' age range appeared to be between 21 and 50. In general terms most people who completed the survey had some experience of TEL although few had either practice or full understanding of the potential that a PLE could offer. It is reasonable to say that there was a fairly even spread in terms of gender across all events. Table 3 summarises the profiles of the participants in each event or activity.

[9] http://projects.kmi.open.ac.uk/ib/.

Table 3 Brief profiles of those participating in selected events or activities

Events	Numbers	Occupation
JTEL Summer School workshop 2011	25	PhD students
SCORE seminar	10	HE e-Learning teachers
OU eLC seminar 2012	20	HE e-Learning teachers
Build a Widget Day	14	e-Learning trainers, managers
JTEL Summer School workshop 2012	14	Ph.D. students
Dev8eD conference workshop	10	e-Learning developers
ITCM seminar workshop	10	HE e-Learning practitioners
Cloud Education Environments workshop	50	HE e-Learning practitioners
The PLE Conference 2012	20	e-Learning practitioners
Activities		
ICALT 2012 paper	20	e-Learning researchers
AACE E-LEARN conference round table	8	e-Learning practitioners

Evaluation Results

The evaluation results will not be described for each of the completed events and activities, but reported for the first group of events only. As previously mentioned, the main research instrument to be deployed for this case study was the PUEU survey. The majority of results of this survey has been recorded for the events and will, therefore, be presented here. A number of the observations made by the ROLE presenters will also be included. In addition, comments and quotes recorded by the participants via the EtherPad widget will also be presented where appropriate. Table 4 summarises the themed groupings of this case study.

The eLC Seminar

The respondents to the PUEU survey appeared to have an even split of knowledge amongst them in relation to TEL. Conversely, however, a significant 88 % of those participants felt that they had “some” rather than a “good” knowledge of PLEs. In other words it appeared that the group as a whole was relatively new to the idea of a PLE.

Observation of the interaction with the EtherPad widget revealed that some participants were hesitant to use this type of technology and required encouragement from their peers or more experienced colleagues (either those in the group or from either of the two ROLE representatives who were facilitating the workshop). The types of information recorded by the participants ranged from anxiety to amazement that such tools could enable individuals to learn collaboratively. There was also clear evidence, however, that a more experienced group member took advantage of the EtherPad widget to communicate with a colleague in another

Table 4 The groups used in this case study

Case study groupings	Carried out	Surveys deployed
1. Seminar and/or workshop	9	Yes
2. Conference dissemination	7	No
3. Bespoke activity	3	No

part of the room about some mutual work unrelated to the subject in hand (i.e. ROLE and PLEs). It should be noted, nonetheless, that the same person used the widget firstly to give advice to his colleague regarding more effective use of the tool before moving onto the separate non-workshop subject. What this also revealed, of course, is that despite encouragement to explore ROLE widgets it was not a compulsory activity and at least one participant chose to continue his own non-ROLE/PLE work as well as participating in the workshop.

It appeared that the EtherPad widget was used more constructively to exchange as well as record pertinent PLE-related information. For example, one participant detailed a blog address that they felt to be "*an interesting take on PLEs. Just a tad off topic*… (*Note to self this is the wiki*)". Others noted comments relating to enquiries about how each ROLE widget functioned. These ranged from "*how are keywords supposed to work*" to "*cannot get ObjectSpot to show on iPad2*". Indeed this idea of recording questions was taken somewhat further by one participant who remarked: "*Why do we need two widgets for search*?"

The final question in the survey asked participants to record their feelings about their use of PLEs. There was a 77 % agreement that PLEs would be slightly useful for participants work, followed by a slight disagreement that the same PLEs would help participants accomplish their work more effectively than their current use of learning technology. Again this was not surprising as most group members were established and experienced users of learning technology and had revealed that they only had limited use of PLEs. Half the group proffered a neutral response to the statement relating to "It would be easy for me to use a PLE" whilst the remainder recorded that there was a slight chance that that would be the case. There was a more even spread of responses to the statement "It would be clear to me how to assemble a PLE using widgets" ranging from slight disagreement (11 %) through to slight agreement (also 11 %). Most participants remained neutral on the subject.

Interestingly, the statement "I would find using a PLE frustrating" invited the most disagreement to be recorded with the majority (55 %) remaining neutral alongside 33 % saying they slightly disagreed and 11 % strongly disagreeing. Once again, the statement "I would find interacting with a PLE requires a lot of mental effort" statement invited a strong neutrality (55 %) yet 22 % of participants strongly disagreed with this premise whilst 11 % recorded that they slightly agreed that this would be the case for them.

The remaining part of the survey related to participants' motivation to using a PLE in their learning process whereby 55 % remained neutral in their responses and 44 % slightly agreeing with this statement. The last statement of "I predict that I would frequently use a PLE if I had access to it" invited an even response (33 %) between slightly disagreeing through neutral to slightly agreeing.

The JTEL Summer School Workshops

A ROLE workshop took place in both the 2011 and 2012 JTEL Summer Schools. The participating research students were enthusiastic and willing to try out the widgets within the ROLE online courses. Each workshop had the same format of an introduction to the ROLE project, followed by the practical activity of using the widgets within the ROLE online courses. In general terms the research students' overall opinion in both workshops was a positive one. They engaged with the structured activities, actively used all of the provided tools as well as recording their thoughts (and sometimes frustrations) in the EtherPad widget.

The EtherPad widget was used in many different ways in the 2011 workshop. Most of the research students used the tool although some were a little surprised by the real-time aspect of it: "*...somebody is writing on the screen*!!!! *I am scared...*" Others considered additional aspects to the experience in that it highlighted some potential gaps in their own skill set: "*...I probably have to work on my search skills...*" By contrast in the 2012 workshop, however, the EtherPad widget was used actively by only a few of the participants. Generally, it functioned as a means to record and exchange URLs of relevant resources such as the "Learn Portuguese language vocabulary" YouTube video[10] that the participant described as: "*This is a great video*". It was also used in identifying a Stephen Downes Slideshare presentation about "Personal Learning The Web 2.0 Way"[11]

All participants in both workshops were aged between 20 and 40 years. There was also an equal 50 % male/female split. In answer to the question relating to the participants' knowledge of TEL, in the first workshop there was a significantly higher response rate to the "some" option whilst in both workshops most stated that they had a "good" knowledge of TEL. In the second workshop with regard to the question related to PLEs, however, there was a greater spread of responses: 50 % recorded that they had a good knowledge whilst 25 % stated a "good" knowledge and the remaining 25 % claimed to be an expert in the field of PLEs. The free-text responses within the questionnaire provided some insight into the participants' views of PLEs as well as the use of the ROLE widgets.

The question: "What did you think of the widgets of the workshop activities?" also invoked a variety of responses in both workshops, most acknowledging that the widgets were interesting. In addition others said: "*I have found them very useful for*

[10] Learn Portuguese language vocabulary YouTube video http://www.youtube.com/watch?v=bzR1q3ZAlKQ&feature=youtube_gdata_player.

[11] Stephen Downes Slideshare presentation http://www.slideshare.net/Downes/personal-learning-the-web-20-way.

my PhD and for my learning" along with a remark that (the widgets were): "*Small apps which can expand your daily routine*". Others simply said that the widgets and interface: "*look good*". It is also important to note a word of caution too though, summarised by one respondent who remarked: "*Found them quite interesting. Collaborative text editor had lower quality in contrast to GDoc, surely I would not use it*".

In relation to the question: "Were you able to find suitable widgets for building your PLE during the second workshop activity?" there was almost unanimous response in the second workshop alluding to the intermittent internet issues that appeared to plague the entire session. One quote, perhaps, sums up the frustration that most participants felt dominated, their experiences: "*Internet connection issues did not let us perform this activity*". Nonetheless, 90 % of the same participants responded positively to the next question: "Did you find the workshop activities useful for your research needs and goals?" which can be summarised by one remark: "*I found it an interesting approach to be tested in the future*". One respondent did, however, offer a rather more circumspect response: "*I do not know. I have to check those pages more when I come home*".

Opinions from both the workshops' attendees about widget-based PLEs were, in general terms, evenly spread. One notable exception, however, was the response from workshop 2: "*I would find interacting with a PLE requires a lot of my mental effort*". Nonetheless, the respondents overwhelmingly recorded that they were neutral in their feelings about this statement for the second workshop. Research students in the first workshop appeared to be more discerning in their learning and, as noted by the ROLE presenter, the majority of the students appeared to focus on the Binocs widget rather than the ObjectSpot widget. Again this seemed to colour their view of the overall experience of using the ROLE technology.

The Dev8eD 2012 Workshop

This workshop was attended by developers and learning technologists, predominantly male and in the age range of 20–50. Most participants recorded that they had a good knowledge of PLEs but some also declared little or no knowledge of this area. Once again the EtherPad was used during the event to record notes and information relating to the workshop that participants wanted to share with each other. In this event, however, the participants took a more strategic view of the EtherPad by using it to store personal observations such as:

> *I've used Etherpad before. The problem with these synchronous writing tools is the way the connection suddenly stumbles and your flow is disturbed—Just had this problem with Etherpad. It was static for a while so I assumed people were still having connection problems—then I clicked to type and got a huge update*!

In addition others used the EtherPad to record their thoughts about the activities themselves as well as how the widgets worked or performed, for example:

> *Some searches return "60 results" apparently—all of them YouTube videos—I untick YouTube as an option and get 54 results—but there were way more than 6 YT videos in my previous list.*
>
> *The term 'reflection' isn't especially useful for search... Binocs' first result may be the kind of 'reflection' I'm looking for but ObjectSpot results cover a range of different types of 'reflection'.*

At the end of the workshop, participants were encouraged to complete the PUEU survey. Again this gave them an opportunity to record their thoughts about both the ROLE widgets, the implementation of them in PLEs as well as the activities of the workshop itself. Responses for the question: "What did you think of the widgets of the workshop activities?" were mainly positive but with reservations about the mechanisms that were used to make the widgets function. Participants were constructive in their observations saying, for example:

> *Could be useful, though a few flaws here and there. Binocs had a odd way of searching and filtering. Etherpad is a great idea but it didn't always sync correctly and would jump-start again when clicked. The Mash-Up Recommender is great but not all widgets were installable to iGoogle!*

There was also positive affirmation that the workshop enabled the participants to be introduced to new widgets, for instance: "*The widget can be useful to put different tools together*" and: "*Useful because I had never heard of or seen these widgets*". Recognition, however, was also given to the technical issues such as: "*Some problems with Etherpad on the iGoogle page—would be better if it sized down. Also the Binocs broke*".

The question: "Were you able to find learning resources that relate to your topic (s) of interest during the first workshop activity?" also invited a variety of responses. Some participants: "*Found some things but would need more time to explore—will do that soon*" whilst others were circumspect: "*yes, though would like to understand better why two separate search boxes. I'm guessing one is API driven, one is custom Google search? could they be combined?*". Remaining responses affirmed that the participants were, generally, happy using the ROLE widgets, for example: "*Yes, I searched for 6lowpan and found some relevant videos and slides*" and "*I tried one topic relevant to my institution. The resources were good*".

There was also overall positive response to the question: "Were you able to find suitable widgets for building your PLE during the second workshop activity?" once again, however, the participants did not hesitate to record their actual experiences of installing widgets or not, for example: "*The ones I did find looked useful but didn't add to iGoogle (there was an error)*". Another participant also remarked: "*I think so, but I'd need to think about how I'd integrate it with my other tools (like Evernote, Twitter, Google calendar)*" demonstrating that as a developer or educational technologist that they were giving some thought to the application as well as implementation of the ROLE widgets.

There was an overwhelming positive response to the question: “Did you find the workshop activities useful for your research/teaching/learning needs and goals?” once again summed up by: “*Yes, a useful overview/primer of what’s possible*” as well as: “*Yes, Very useful*”. Similarly the final question of the survey offered participants the opportunity to add any remaining questions, comments or suggestions that they wished to record. Some insightful comments were made such as:

> *I still have lots to learn about this area but this was an informative session to get me started!” as well as: “I can’t help thinking that if I have the digital literacy skills and confidence to create a PLE then I don’t need a PLE. (a bit of a paradox!)*

Lessons Learned

From earlier, interim, research about this case study (Mikroyannidis and Connolly 2013a) three main themes were identified:

- The usability of the learning tools, i.e. the widgets.
- A consideration of the types and styles of related learning activity formats (often embedded in the ROLE online courses).
- A reflection as well as action upon suitable methods that might encourage future participants to consider, engage and continue using PLEs for their own learning purposes.

In respect of the additional events, activities and artifacts described here it can be reported that a number of further lessons have been learned. These will be considered in the context of successes and failures. The underlying lesson learned was the importance of ensuring that all the technologies are stable, available and accessible at the time of engagement as this leads to successful deployment. Additionally, planning an event, activity or even an artifact should also include a level of adaptation or localisation for particular audiences e.g. PhD students have different requirements to the more experienced researchers.

The creation of the first ROLE online course alongside the development of the second ROLE online course focused on SRL were invaluable in the success of all the components described in this case study. Each course had been structured in a similar manner (using the same template) and thus contained learning outcomes, defined learning activity opportunities and clear signposts to relevant ROLE widgets. Thus the use of such structured content made its repurposing as an eBook much easier to carry out. Consequently, it was possible to build on the success of both ROLE online courses by raising awareness about PLEs and SRL through an additional informal based educational channel: the interactive eBook was developed. Similarly the eBook reused the previously developed course template by providing an introduction to PLEs and SRL as well as giving an opportunity to readers to try a selection of ROLE widgets through a set of embedded interactive learning activities.

Successes and Failures

The level of success for this case study can be measured in a number of different ways. Both qualitative and quantitative data has already been presented that outline both the positive and negative impacts that were observed by ROLE presenters or recorded by participants in the PUEU survey. Most participants were willing and able to take part in the ROLE workshops although some were hesitant to use this type of technology. Those people sometimes required encouragement from their peers or more experienced colleagues in order that they make progress. Most of the free-text responses recorded in the PUEU survey ranged across the possible spectrum of experiences from anxiety to amazement in terms of the potential use of such widgets to enable collaborative learning for example. It is fair to say, with this supporting evidence, that the case study has been successful in terms of raising awareness of PLEs to a cross section of HE staff and groups of research students.

It would be unfair to state that there were direct failures in this case study. Nevertheless, it should be noted that when technology was intermittent in terms of access this had a dire influence on the experiences gained by those attempting to complete the workshop activities. Frustrations with widgets not fully working or a simple breakdown in internet access had a very negative impact on all participants but in particular proved to be major stumbling blocks for those who were less confident or competent with the PLE or individual widgets.

Best Practices for PLE Adoption in Informal Learning

As a result of recording the successes and reflecting on some of the perceived failures in this case study, it is possible to list a set of best practices for the adoption of PLEs by informal learners:

- *Accessible and easy-to-use tools*: Best practice in this case study indicates quite clearly that a simple format for the ROLE tools is required that enables a range of learners to use them effectively and efficiently.
- *Multi-format introductory and guidance learning course materials*: Learners are in need of guided learning materials that will help them understand the value of the new technologies. Best practice in this respect included the development of the ROLE online courses and the ROLE eBook.
- *Tailor tools to meet the needs of specific subject audiences*: Best practice here should be to enable adjustment or even design for learners studying particular subjects or, alternatively, educators researching a wide range of topics to be implemented as required.
- *Tools that harvest information from appropriate repositories/platforms*: A set of generic search widgets were fully tested in this case study thus enabling use across a variety of learning contexts. As a consequence, some ROLE widgets

(e.g. Binocs and ObjectSpot) have been successfully used and repurposed in other test beds of the ROLE project.
- *Fostering a culture with a community willing to engage with new innovative technology*: In order to maximise the adoption of PLEs, a suitable culture towards new technologies needs to be fostered. This case study demonstrates that the teacher or trainer may also need to adapt their own approach in order that they too are receptive to change.

Conclusions

The different components of this case study have enabled us to extend our understanding of the potential impact of the ROLE technologies within a wide variety of informal learning contexts and scenarios. This case study has numerous rich contexts in which there is potential for significant impacts of both PLEs and SRL. The challenges faced and lessons learned in each component of this case study have also been reported here. As with every new technology, some resistance was expected and initially faced in most cases by the participants be they educators or managers in HE institutions or likewise e-Learning practitioners elsewhere. Overwhelmingly, however, most of the ROLE tools were positively received by those who participated in the events, activities, or used the artifacts. Each event, activity or artifact that has been explored has also involved a cross section of representative individuals. This approach has enabled the ROLE project as a whole to collect experiences covering a large variety of learning contexts and requirements.

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Case Study 4: Technology Enhanced Workplace Learning

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Abstract Within the ROLE research project it has been evaluated how personal learning environments (PLEs) perform in different surrounding conditions. Companies do often lag behind in the state-of-the-art developments from research especially in terms of Technology Enhanced Learning. Festo therefore observed on its internal test bed how PLEs can be implemented in business contexts and how to involve the learners in this process. Since there is already a broad variety of tools to organise and manage formal learning processes within companies the test bed didn't start by scratch either. The focus was thus on how to open up an existing learning management system (LMS) towards a PLE. During this process many experience from both learners as well as administrators, and training organisers have been gathered. One of the lessons learned is that a pure PLE doesn't fit the requirements on personnel development in business context, but certain PLE aspects can improve individual learning processes significantly. One showcase is the Festo LearningTube which was developed during ROLE. This is an example for the successful integration of user generated content into a corporate LMS.

Keywords Technology enhanced workplace learning • Personal Learning Management System • Evaluation • Test bed

Challenges and Solutions in Technology Enhanced Workplace Learning

The competitiveness of a company depends strongly on the skills and abilities of its managers and employees. The development of information and communication technologies (ICT) offers a wide range of tools and application options or even completely new forms of learning in this regard. Thanks to the development of the

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Internet in particular, new multi-media learning scenarios and teaching methods increasingly complement, compete with and even partially replace classic classroom-based teaching.

While these are usually large companies in the field of formal learning which have been able to establish themselves in the area of classic e-learning or blended learning concepts on the further education market and in the field of staff development, technologies and learning scenarios for promoting informal learning in the workplace are given even less consideration or fail before they have got off the ground.

Why is this so? The idea of setting learning processes in motion or even optimising them simply by using new learning technologies for planning, performing and reflecting on further education courses, is just as harmful as the complete ignorance of such usage scenarios and potential. Not only technical requirements, but also media-didactic conception and design aimed at specific target groups are crucial for the efficient integration of learning technologies, which are usually web-based educational applications.

Teachers and learners within companies often lack media competence and the ability to apply self-regulated learning (SRL). Thus, train-the-trainer concepts for these skills are needed. Something that should not be underestimated is that innovative approaches often also fail due to the lack of willingness to change or poor implementation.

Trends in Technology Enhanced Workplace Learning

In the last years, the rapid changes in business environment set new requirements on the development of learning methods, as well as learning software and content. The experiences of the last years show that the curriculum-based learning approach, based on the assumption that the learner "consumes" knowledge in the form of predefined learning content, was continuously extended with SRL approaches based on the cognitive learning theory. This happened through the active involvement of the learner into the learning process, that is planning and defining the learning strategy, searching for appropriate methods, tools and materials, time management, reflection, and undertaking corrective actions. Such characteristics as adaptivity, responsiveness, and personalisation became, thus, mandatory for the modern learning software solutions.

Also, the penetration of mobile media, such as smartphones and tablets, into the Technology Enhanced Learning (TEL) branch caused significant changes in the conception and realisation of workplace learning activities. The possibility to use small software applications and pieces of content ("learning nuggets") became an indispensable component of virtual learning environments making the learning process time and place independent and optimised for mobile devices. Further, the "socialisation" of the web (e.g. the emergence of social networks, social sharing platforms, micro blogging, and so on) caused continuously increasing application of social media technology in education, using software tools supporting communication, content sharing, joint learning activities, and providing mutual feedback between the learners.

Thus, the following trends/challenges in terms of workplace learning have been observed:

– Increasing networking of the learners (collaborative learning/social learning)
– Creation of smaller, highly concentrated learning content (micro learning)
– Increasing importance of mobile learning ("bring your own devices")
– Individualisation and self-regulation of the learning processes (PLE approach)
– Videos as the learning medium with increasing potential
– Increasing importance of specific (experience-based) knowledge and user-generated content

The ROLE Solution

While learning, software met the requirement of becoming user-centred, flexible, and social, organisational structures needed more time to adapt to the new trends. The evaluations conducted within the scope of the ROLE Project showed that the vocational training and workplace learning providers appreciated the SRL approach and the idea of personalisation of the learning tools and content. On the other hand, they wanted to keep control over the learning environment, as well as tools and content provided to the end users. Further, it became obvious that the implementation of SRL in an organisation needed the development of specific competencies by the learners, as well as guidance through the learning process from its very beginning.

Thus, a learning software solution allowing combination of curriculum-based and SRL approaches, and providing both standard functionalities and content and personalised tools and materials has become necessary. To address this requirement, the ROLE Project developed a Personal Learning Management System (PLMS), which is an OpenSocial-based Learning Management System (LMS) combining functionalities of a LMS and a Personal Learning Environment (PLE) and allowing users to construct their virtual learning environment according to their learning history, goals, and preferences.

The following sections describe the main pedagogical and technical concepts underlying the development of the ROLE solution from the point of view of Festo, a test bed which actively contributed to the development, testing, evaluation, and application of the ROLE approach and technology. The Festo Showcase describes (a) the development and application of a learning video sharing portal (LearningTube), (b) the extension of the corporate LMS with additional web-based learning applications (widgets), c) the evaluation of the PLMS developed based on the corporate LMS and including external learning widgets.

Technology Enhanced Workplace Learning at Festo

The Learning Company Festo

The Festo AG &Co.KG was founded in 1925 by Gottlieb Stoll and Albert Fezer in Esslingen, Germany. Initially, it manufactured wood cutting tools and later diversified into the automation industry. Now Festo is a leading, worldwide supplier of automation technology with approximately 30,000 catalogue products, customised solutions, ready-to-install automation systems, and a matching range of before- and after-sales services. According to the Engineering & Production on-demand concept, users can adapt these solutions to their individual needs, which actually increases the number of products offered exponentially. Furthermore, Festo is the performance leader in industrial training and education programs and offers a comprehensive range of learning systems for industrial training and education—from seminars, training and consultancy in 26 languages to e-learning and complete turnkey learning centres. Some 42,000 customers worldwide take part in Festo's seminars or are educated at the company's own training facilities. In 2012, the Festo Group had about 16,200 employees and a consolidated turnover of €2.2 billion. The 61 independent national companies serve customers in over 250 offices in 176 countries worldwide.

Festo AG & Co. KG defines itself as a "learning company" which would like to constantly expand the knowledge and potential of its employees in order to encourage technical innovation and product development. Festo is a globally-oriented and independent family company with its headquarters in Esslingen. The largest production and logistics site is in St. Ingbert/Rohrbach, which is home to the cylinder production, the Customer Service Center and the Festo Learning Center.

The Festo Lernzentrum Saar GmbH (Festo Learning Center)

The Festo Learning Center was founded in 1994 and is located next to Festo's production plant and logistics centre in St. Ingbert/Rohrbach, Germany. As an accredited institution for advanced vocational training, the Festo Learning Center offers a wide range of personnel and organisational development programmes. The service portfolio comprises the whole spectrum of further education (seminars, training courses, the private technical school "Festo Technikum"), subsidy consulting, vocational retraining and qualification, industry consulting, and e-learning. The customers are international enterprises of all branches and institutions, as well as Festo employees and private persons.

Within the ROLE project, the Festo Learning Center aimed to define requirements of how to create a ROLE environment within a professional industry business. The Festo Learning Center wanted to demonstrate the use and benefit of ROLE technologies for the learners by addressing and supporting them in planning, realisation and evaluation of qualification measures with the help of the web-based services on the Festo Virtual Academy—Festo's global e-learning platform.

The Virtual Academy

The Festo Virtual Academy is the central LMS of Festo with a corporate internal focus. It is based on the software CLIX developed by IMC (see section "IMC and CLIX Learning Suite"). The LMS supports personnel development processes within the Festo organisation and offers strategic relevant online courses to the learners.

The Virtual Academy is open for each Festo employee worldwide for their personal further education by means of the lifelong learning approach. The LMS is accessible via the internet to facilitate SRL processes for the employees (learning independent of time and place). In addition to the self-learning offers, several blended-learning modules are available. The web-based trainings (WBTs) are designed according to didactic models in order to make their "consumption" as easy as possible for the learners.

The Virtual Academy has more than 9,000 users distributed all over the world, more than 80,000 logins p.a., more than 800 learning contents in different strategic learning categories with a total learning time of approximately 2,000 h. The contents are provided mostly in German, English and Spanish. For specific topics additional languages like Chinese, Japanese, Portuguese and Russian are also available.

In the ROLE project, the Virtual Academy was one of the five original test beds and addressed the issue of providing a responsive learning environment within further education activities in a company. This included not only continuous technical and media-didactical possibilities of a LMS and the content within, but also the technical possibilities beyond the LMS approach.

The application of ROLE at Festo led to better support of individual learning processes (in terms of self-regulation) and also better support of collaborative and social learning in a company. Therefore, informal learning increases its importance for the workplace learning and also the possibilities to record, share and save this expert knowledge within the company.

The following chapters describe the most important TEL-topics for the current and future developments of the Virtual Academy as well as the ROLE project with the Festo test bed, especially

– The initial situation
– The project vision
– The specific target group
– The characteristics of the business context
– The main organisation related challenges and the requirements
– The technical implementation
– The evaluation of the project results

Trends of Technology Enhanced Workplace Learning at Festo

Making Learning Environments More Personal

The PLE approach is nothing particularly new, but is still a vital research topic in the TEL-community. PLE stands for a PLE, i.e. an individual composition of learning services that helps learners to plan and conduct their learning activities, and to reflect on the learning process and progress. Considering the fact that learners are often a very heterogeneous group (with different learning needs and goals, learning styles, individual learning experiences, knowledge, learning preferences or different job roles), the potential of the PLE approach is undisputed.

In 2007, Graham Attwell (2007) defined a PLE as being "comprised of all the different tools we use in our everyday life for learning". Considering this quote alone, one can be of the opinion, that in business contexts, especially in e-learning, every employee has already developed a PLE consisting of standard and company-specific software as a digital toolbox. But far from it, at the moment the PLE approach is more theory than it is implemented in further education scenarios or personnel development processes in companies. It seems that further education is more and more lagging behind technical developments.

The main hurdles for the TEL implementation in companies are:

– At the moment, learning processes in companies are unilaterally strategic driven in a top down manner.
– Most of the learning processes are formal. The potential of informal learning and user generated content is not being exploited. The paradigm change of content towards the expert as author is not yet turned into practice in companies.
– Companies have already made big investments in learning technologies (perhaps in e-learning content or an LMS) and promote only these.
– Frequently there are a lot of existing internal learning tools in (bigger) companies, but these tools are often not synchronised. Therefore, the promotion of new learning tools across departments is very difficult.

Consequently, the Festo test bed examined in ROLE how the PLE approach can enhance learning opportunities for employees. The target was not to create a "pure" PLE, but rather to combine advantages of a PLE with an existing LMS. Thus, it was not a question of replacement or substitution of an existing, traditional LMS in a company but rather an approach that enabled the enhancement of their current delivery mechanisms. It was also a question of how an existing LMS can be enriched with new information and communications technologies that accordingly enhance the end-user (the learner's) experience. This will be explained in detail in the section "Implementation of the Personal Learning Management System".

Videos as the Learning Medium of the Future

The power of the image is used on the Internet to disseminate information quickly and easily. Photos and graphics are omnipresent in the worldwide web today—be it for advertising or promotional purposes, to inform or simply to spread a bit of happiness. Today's technology makes it very easy for each and everyone of us to create pictures or videos and publish them on the Internet. Individual users already actively use video production and sharing to exchange experiences and knowledge. The trend towards video-based learning is being adopted by private companies and higher education.

Pioneers in this area include the Khan Academy[1] with a thematic collection of over 4,100 instructional videos and Stanford University, which operates its own YouTube channel.[2] However, the YouTube channel alone is not the impressive fact, but those 215,289 subscribers downloading over 55 million videos on demand, illustrates its reach. The private online academy Udacity,[3] founded in 2012, provides similar figures. The philosophy here is "Learn. Think. Do.—Higher Education for Free". The first two free video-based online courses alone reached 90,000 participants (Lewin 2012).

The key to the success of these video tutorials is the didactic simplification through visual representation. Wherever one previously had to describe a subject in words, written or verbally, or how complex product drawings had to be created, today it is simple to visualise information using moving, narrated images. This usually saves the knowledge carriers and producers of video tutorials more than just time in comparison to creating professional teaching materials or specialist articles. The creator of a video tutorial is able to use the sound and video track to give his "knowledge" not only a personal note but also a kind of personal signature.

The knowledge content is closely connected to the knowledge carrier and these are not as easy to separate as in the case of pure text-based content. Thus, statements, opinions and experiences can be expressed personally through interviews and the interviewed person "signs" it with his name. Ultimately, the web video medium suites often better to meet the need for communication and self-expression than "pure" text. From the learner's point of view, particular application or process knowledge is taken in more easily via pictures and transferred to "real life" than when if it is read from texts. The recipients also use their auditory and visual sensory paths to process information, which helps to anchor it in the memory.

Festo has recognised this trend towards instructional videos. It developed an award-winning tool, the LearningTube and Recorder, as part of the ROLE research project. The LearningTube provides all Festo employees with a simple way of creating video tutorials and sharing them with colleagues in the company in order to document best practices arising in everyday work and make them available for

[1] http://www.khanacademy.org/about

[2] http://www.youtube.com/user/StanfordUniversity

[3] https://www.udacity.com/us

colleagues, successors, and new employees. The innovative aspect of that is the combination of the LMS with easy-to-use authoring software which allows content owners as well as every learner to instantly create learning content on their own. Compared to traditional LMS that only had "time-consuming" text-based authoring tools included, the screen recording capabilities of the LearningTube make it much easier for the authors to capture their knowledge and transform it into learning content. The reason for the perceived simplification is that experts can easily reuse the tools and media they use in their everyday life to transport the information such as PowerPoint slides or recording the software they need to explain. Thus they do not need to develop new skills, the system is built on the skill-set the experts already have.

The ROLE Project and the Festo Test Bed

Project Vision

Learning in the Virtual Academy Before ROLE

The learning processes at Festo can be described as self-controlled by the learners (employees). The users browse offered learning programmes in the catalogue of the Virtual Academy and select those they need. During the learning process itself, the learners can decide by themselves what they would like to learn and which parts of the web-based training content they would like to skip. Since the platform is available online, the learners can even access the Virtual Academy from home and participate in trainings on a voluntary basis. The learners are free to define and plan what and when to learn, and how frequently to work on the web-based training offered in the catalogue.

The vision of the ROLE project was to improve especially the aspects "responsive" and "open" of the already existing learning environment of Festo—the Virtual Academy as the central LMS of the company. From Festo's point of view the main targets were to improve existing learning systems according to:

- Openness and adaptivity
- Communication with other learners
- Facilitation of collaboration and peer-assisted learning
- Switch collaborated and individual work
- Exploring ways of benefiting from the experience acquired in a company
- Best practice sharing

Challenges and Requirement Analysis of the Test Bed

The Festo Learning Center aims to meet the requirements of learning environments within a business context. To achieve this aim, Festo effectively opened up its platforms and tools to “mix and match” and be interoperable through the use of ROLE tools and technologies.

Organisation Related Challenges and Requirements

Since the Festo Virtual Academy is effectively a corporate learning environment, some special surrounding conditions have to be considered within the ROLE process. These special “challenges” depend on the fact that a corporate LMS has one central main function: the further development of personnel in the company.

Issues relating to these surrounding conditions are, for example:

- The uncertain scope of openness of a corporate learning environment. How wide can a corporate learning environment be opened up?
- The “job role” of the learner has to be in the focus of all learning processes
- Knowledge sharing is harder to realise in the job context than in non-working life
- Understanding learning processes during daily work and after work
- System restrictions and data security

Target Group Related Challenges and Requirements

The Festo test bed is focused on LMS users and especially LMS users in a company. This target group has special needs and the surrounding conditions in companies are not as flexible as those predominant, for example, in universities. In contrast to students, business learners are a very heterogeneous target group with big age differences (from 16 to 65), different educational backgrounds and previous knowledge, job-roles, learning requirements, learning preferences and learning goals.

Further, the learners in business environments have primarily to fulfil their job role and learning is mostly to support them in doing so. Due to high workloads, it is often hard to learn on the job or in other words, there is no or just little time for learning available. It is often not so easy to disengage workers from their daily practices. Thus, learners at the workplace need to be supported systematically, not only with new TEL solutions, but also with their development goals, the working and learning conditions in general and their work life balance.

User Related Challenges and Requirements

There is one more aspect to be considered, which is related to the personal requirements of the learners. The learners need a set of specific skills, the so-called "self-regulated learning" (SRL) skill-set. These are skills the learners must have to be able to successfully plan, conduct, and evaluate their learning activities. Some of these skills might be new to some learners, whereas others might be present and used already, but the awareness about that fact is still missing.

To address this requirement, Festo initiated the "Fit for Self-Regulated Learning" initiative in the ROLE project. The plan was to implement various SRL learning modules in the offered ROLE service. Some of the modules should explicitly show that they support learners in getting SRL known as a method. Others would be implicitly woven into ROLE services to make their impact on SRL visible, for example within wizards.

Putting the idea behind "Fit for self-regulated learning" in a nutshell, one can state that SRL should improve the learning outcomes. This is realised by offering the learners SRL as a manual. This would not be a technical description of the platform, but rather a manual for learners that shows how to learn effectively and successfully in the ROLE environment with the help of SRL.

Festo considered the benefit of the approach to be very high and therefore decided to personalise learning through ROLE and made learning more demand- and service-oriented for the users of the Festo Virtual Academy.

Implementation of the Personal Learning Management System

IMC and CLIX Learning Suite

IMC is currently Europe's largest learning management solution provider that was established in 1997 by Prof. Dr. h.c. August-Wilhelm Scheer as a spin-off of Saarland University. IMC offers a comprehensive portfolio of e-learning-related products, supporting all business processes in training and education. IMC also provides professional services covering the whole value chain of content design and production as well as consulting and managed learning services helping clients to (re)organise their learning processes and to select, implement, adapt and integrate suitable software systems and technologies.

IMC's product portfolio includes professional authoring and content recording tools (Content Studio, LECTURNITY), a Business Process Guidance System LIVECONTEXT, as well as a Learning and Talent Management System CLIX supporting HR- and Personnel Development processes at organisations. CLIX contains two main modules: the Learning Suite, which is a LMS in the classic sense, and the Talent Suite supporting Talent Management processes, such as

Talent Identification, Competency Management, Career and Succession Planning, Performance Management, etc.

In scope of the ROLE Project, IMC used CLIX Learning Suite to implement the concept of the Personal LMS. CLIX Learning Suite in its basic configuration includes such functionalities as Organisation Management, Process Management, Content Management, Testing and Assessment, Resource and Capacity Management, Report and Compliance, Evaluation, and some others. The Social Learning module contains communication tools, such as chats, communities, wikis, and forums allowing making use of the synergy effects of collaborative learning.

In order to increase personalisation of the system and to extend collaborative functionalities, CLIX Learning Suite has been integrated in scope of the ROLE Project with an OpenSocial PLE, thus, constituting a so called Personal LMS. The PLMS aggregates learning resources and applications available in the web and selected by the users. Its structure aligns phases of the SRL process and assists the users in planning of their learning activities, search for learning content and tools, training and testing, as well as in reflection and evaluation of the learning progress.

Addressing the increasing need in acceleration of the knowledge acquisition due to rapidly changing organisational and technical conditions at organisations, and in personalisation of the learning process increasing employees' motivation and effectiveness of the training measures, an adaptable learning environment supporting workplace learning had to be developed. The identified requirements from the user side were: firstly, for the learner's point of view, to make the system customisable in terms of tools and content according to the current learning needs, and secondly, from organisational point of view, to keep control over the learning environment to ensure transparency of the learning process and the achievement of planned learning results.

From LMS to Personal Learning Management System

The early development of LMS is aimed at coordinating the learning processes in organisations in terms of training measures participant and content management, including creation of course curricula, adding learning materials and tests, as well as providing meta-data such as course dates and place, procedure of entering the course, course completion and certification. Over the last years the LMS developed in the direction of the Human Resource Management Systems (HRMS) providing functionalities for personnel assessment, competency management, learning and development, as well as succession planning. While increasing the planning and organisation capacity of the LMS, the learning process supporting infrastructure has not changed much.

The new learning approaches, such as SRL, collaborative and social learning have been realised in PLEs allowing the users to construct their learning environments themselves by selecting learning tools and content in a way supporting acquisition of the desired knowledge. In scope of the ROLE project, a PLE is a web-based infrastructure, where the users can access, aggregate and manipulate learning applications and resources of their preference, as well as communicate with other users sharing experiences and collaborating on projects (Overton 2009). Importantly, the PLE uses web widgets, which are small web-based software applications, to support particular learning and teaching goals or training of some specific skills.

In order to create a software solution supporting both approaches, an OpenSocial PLE has been integrated into LMS combining functionalities of both systems. Thus, the PLMS provides instructions and pre-defined learning materials allowing the users to complete learning courses as usual, but also it ensures the learning process autonomy offering personalised learning spaces, in which the users can add and use additional applications and resources. Further, the PLMS allows browsing additional learning content directly out of the system with help of the Media Search Widget, thus, being more open than classic LMS. Also, it offers guidance through the SRL process and support to its each phase, which are described in the sections below.

Psycho-Pedagogical Integration Model and Personalised Learning Spaces

The OpenSocial directory of the PLMS is structured according to the phases of the SRL process described in the Psycho-Pedagogical Integration Model (PPIM) developed in the ROLE Project (Fruhmann et al. 2010). This model identifies four main steps:

1. *Plan*: This phase includes definition of the learning strategy, learning goals, actions to be taken to achieve these goals, as well as preferences in the sense of tools and types of content that will be used.
2. *Search*: At this step the learner searches for learning resources and tools within the learning environment and outside of it. Here, the user may get recommendations from tutors and peers, but also use recommendation systems to find appropriate resources.
3. *Learn*: Learning includes studying of the selected tools and materials, attaining skills, training and testing, as well as assessment by tutors and self-assessment.
4. *Reflect*: This phase implies gathering feedback from different sources and self-evaluation, as well as reflection on the learning process and achievements in order to evaluate the usefulness of the learning strategy and particular actions and their correction if needed.

These phases are summarised as "plan-search-learn-reflect" loop (see Fig. 1 (Mödritscher and Nussbaumer 2012).

The OpenSocial directory of the PLMS is divided into four learning spaces corresponding to these four steps. In order to provide necessary guidance to the

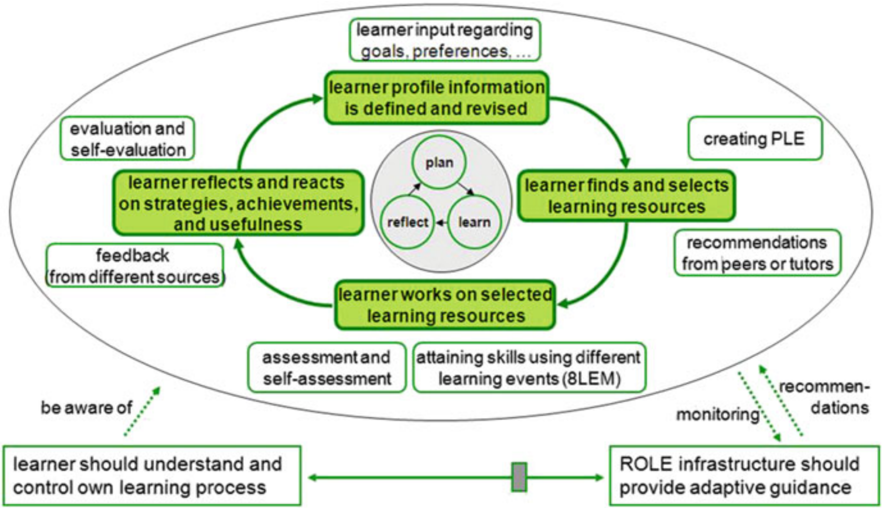

Fig. 1 Psycho-pedagogical integration model

users, each learning space is populated with pre-defined learning widgets. These are Open Source tools that were developed by the ROLE project or found in the web (all rights reserved) and reviewed concerning their suitability to support one or more of the learning phases. Further, the PLMS contains a list of additional tools. Thus, the users may use pre-defined applications and/or supportive tools from the list arranging them in the learning spaces. This allows an efficient integration of external tools into the system respecting the interests of both the learners and the organisation (Fig. 2).

Besides learning applications, each learning space contains an introductory video to the respective phase of the SRL learning process and a Wizard Widget containing supporting questions and hints to assist the user in getting started with using the system. The user acceptance evaluation showed that the availability of these assisting tools was highly appreciated by the users (see Evaluation section). Thus, the PLMS aims at providing as much guidance as necessary, and as much assistance as possible (Schanda et al. 2012). The development of the PLMS and its technical implementation focused on the personalisation, adaptivity, and user-friendliness of the PLMS making it responsive to the needs and preferences of the users.

Technical Implementation: OpenSocial LMS

In scope of the technical implementation, two major aspects were identified in order to extend the CLIX Learning Suite to be used as PLMS: on the one hand, a mechanism was required to enable the integration of external components into

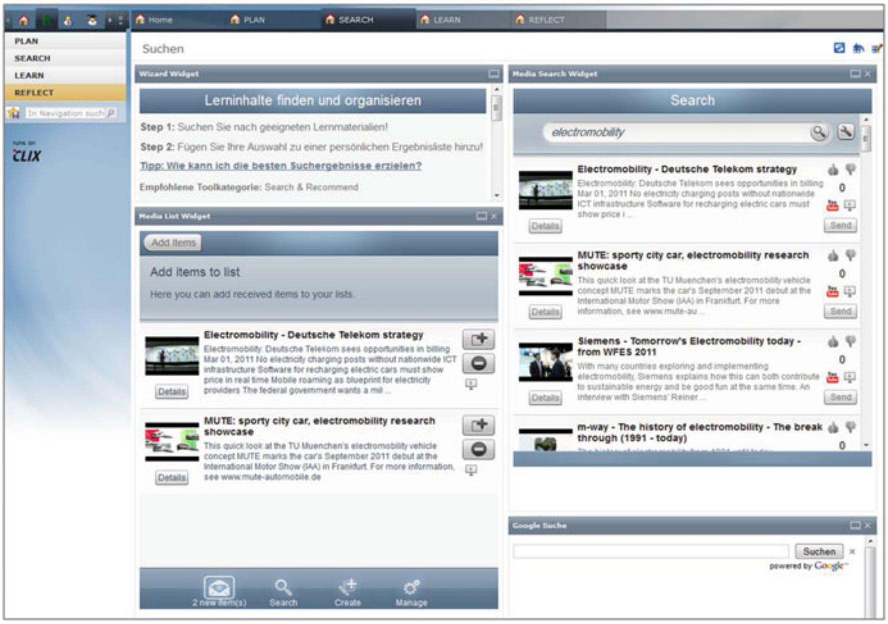

Fig. 2 ROLE PLMS search learning space

the CLIX portal. These components had to be implemented using a standardised technology for the following reasons:

– In order to separate the development processes and technologies for components of PLMS from those of CLIX.
– To enable external developers to create components without technical knowledge of the environment they are embedded in.
– In order to allow integration and re-use of existing components, e.g. components which are provided in the repository.

On the other hand, an interface was required to exchange social information between PLMS components, CLIX as a hosting environment, and external services.

Taking those requirements into consideration, the decision was made to use OpenSocial[4] as an open cross-platform standard specifying a REST-API to exchange social information. Having the API specified, the technology stack was completed by supporting the Google Gadget specification[5] to create components, further on called widgets. Widgets are applications designed to only take small parts of a screen and make use of web technologies (HTML, CSS, and JavaScript). For the communication between the widget and the environment, a JavaScript API was provided, which also included the interfaces of the OpenSocial API.

[4] http://opensocial.org

[5] https://developers.google.com/gadgets/docs/spec

The implementation of the OpenSocial API and Google Gadget specification was based on the Apache Shindig project.[6] Apache Shindig was realised as a standalone web application, which was connected over a dedicated web service interface with the CLIX Learning Suite. This architecture allowed separated maintenance processes for both platforms. Shindig took two roles within the PLMS: as rendering server for widgets and as OpenSocial API provider. CLIX acted as data provider and environment for embedding the widgets rendered by Shindig.

At the next step, an integration point for the widgets inside the CLIX portal had to be found. As the PLE structure does not necessarily depend on a concrete course, the integration was realised using dashboard pages. Dashboard pages were designed to create a mash-up of panels showing user-centred information (e.g. a course list, news, social media updates, etc.) and therefore built a capable environment for widgets. The implementation aimed to provide a seamless integration with existing dashboard features. A new panel type was introduced and each instance of this panel represented a single widget.

Platform administrators can select which widget panels are available on a dashboard page and can pre-configure the widgets. They can choose if a widget has a system-wide or a user-specific configuration. In the latter case, the users have their own configuration interface for the widget directly integrated in the dashboard page.

The final layout and content of a dashboard page allow nearly any degree of personal individualisation. Whilst the pool of available widgets is previously defined, their visibility, application, and position can be made customisable for the individual user. The range of self-controlling is therefore very large; both settings of fully pre-configured widget mash-ups and open-space solutions, where users combine widgets starting from a blank page, are possible. Learning processes can also be supported by combining multiple dashboard pages, covering either different steps in a learning process or different topics addressed by specific pages.

Concept and Evaluation of the PLMS at Festo

The Virtual Academy Case study

This case study reports on how the ROLE environment can be open to a mix of internal learning applications alongside external ones. This is regarded as a key success factor for project ideas that emerge from developments like ROLE to influence the promotion of further education in companies and meets the overarching premise of this case study namely that it demonstrates "an internal learning opportunity in a company" environment. In essence, this section, thus, presents an

[6] http://shindig.apache.org/

evaluation of a case study relating to the Festo Virtual Academy and demonstrates how internal learning opportunities can be improved in a company.

This case study therefore sets out to address the issue of providing a more responsive learning environment within the further education activities of Festo. As previously indicated, to achieve this aim, Festo opened up its e-learning platform to be interoperable and open for mixing and matching with ROLE tools. This combined approach was called a “Personal Learning Management System” (PLMS), where the PLMS was comprised of the LMS and PLE together, hence when combined resulting in the acronym PLMS as technically described in section “Implementation of the Personal Learning Management System”.

The actual implementation of this approach, i.e. the degree to which these PLE enrichments are embedded, ultimately depended on both company-specific requirements and on the individual learning preferences, as well as the anticipated learning experiences of individual learners. In general terms, however, the main targets of the PLMS approach were:

– Simplified access and advanced search of relevant content and learning materials.
– Support and improvement of the planning of learning, incorporating the reflection phases of the learning activities.
– Enabling learning motivation and promotion of SRL as well as different forms of cooperative learning.

To achieve this improvement, Festo supported ideas and the development of prototypical widgets and tools, which can enhance the learning processes in such corporate learning environments. Initially, the first item to be addressed during the implementation of the ROLE approach was to improve the “Openness” of the system.

At the first step, a federated search widget was developed together with two other ROLE partners, namely IMC and KU Leuven. The idea of the widget was to enable a more focused search facility in the Festo LMS. It was developed to search learning content in several external online resources and feed results back directly to the learner within the Festo LMS. A media-list widget, that was interoperable with the federated search widget, was developed too. This allowed users to create media lists out of the resources found with the search widget. Both widgets are featured in the Festo Virtual Academy.

At the second step, another perspective of openness considered in the context of this case study was the integration of user generated content as well as encouraging the possibility for learners to produce content on their own. To achieve these outcomes, a commercial screen recorder facility was embedded as a widget, which enabled learners to create their own videos. This widget bundle was given the names of “LearningTube” and “Recorder”, and together both widgets provided all learners, trainers and experts with appropriate support for exchanging and communicating training content on a daily basis.

In this case the Recorder allowed users to create a video, which could then be uploaded to the LearningTube and shared with Festo colleagues worldwide. Both

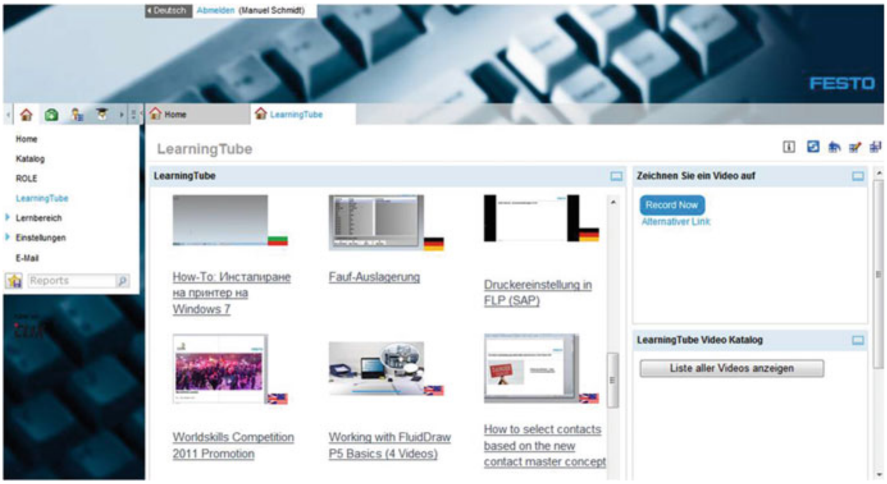

Fig. 3 The Festo LearningTube

tools supported bite-sized learning and ensured that content could be published and distributed quickly. This style of rapid e-learning, therefore, allowed users to enhance their presentations with the addition of a voiceover and optional webcam video. The Recorder widget also provided help and support for creating resulting screenshots, enabling users to add their own commentary to PowerPoint presentations or even enabling them to emulate software simulations.

The LearningTube widget bundle was acknowledged by the Comenius-EduMedia organisation, which gave an award for the practical application of educational, thematic and design excellence in educational media. Festo was the only industrial enterprise to receive such an award. Equally, the widget has offered to Festo employees around the globe, an interactive educational video channel that has also become a valuable learning tool. As a result of this implementation, there have been over 220 video uploads by Festo employees since July 2011, consisting mostly of screencasts and recorded presentations. These videos have been accessed over 15,000 times to date (April 2013) (Fig. 3).

Evaluation

The concept used to evaluate the ROLE solution at Festo consisted of a combination of questionnaires, selected expert interviews, a focus group for requirement gathering purposes, a taskforce observation and interviews by project members. These various elements ensured that there were standardised frameworks for evaluation and also personal contacts to offer possibilities to clarify confusing questions and allow a little more depth.

During the project, Festo carried out two main evaluation loops. To this end, Festo founded a small focus group of 26 colleagues to test and evaluate the ROLE technologies in the Virtual Academy from the learner's perspective. Qualitative data about the usefulness, usability, look and feel, the innovativeness, the relevance, the clarity and the improvement potential of the presented ROLE technologies were collected. Therefore, the first evaluation loop was conducted by a specific questionnaire, whereas the main focus of the second evaluation loop was to observe how the test persons work with the learning technology.

The use of the focus group meant that although the evaluation was not on a large scale, the results were of high quality. This was due to the expert knowledge, the aforementioned method mix and the possibility to read between the lines and to receive more detailed feedback.

The First Evaluation Loop

As described, the first step was to implement two widgets in the existing Festo Virtual Academy LMS, thus, enriching it with appropriate PLE elements. The first evaluation loop consisted of a questionnaire about the developed media search and the media list widgets. The evaluation of these widgets was not possible with the existing standard questionnaire of the virtual academy. Therefore, a new questionnaire, asking about personal information, preferred forms of further education, daily use of the internet, affinity to Web 2.0, benefit of web 2.0 and the described widgets, was created. This questionnaire was emailed to the members of the previously described focus group; a screencast introducing the ROLE project, the ROLE approach, and the developed widgets was attached.

Results

The response rate of 61.5 % (16 of 26) was not as high as expected, but it should be kept in mind that the members of the focus group had to give priority to their normal jobs and the effort required in the different evaluation loops had to be reasonable. The focus group supported the Festo project team on a voluntary basis partly in their leisure time. So their resources and feedback were important, but also very limited. All responses to the questionnaire in this case study regarding the look & feel, usability and perceived usefulness were very positive concerning the applied ROLE approach in the business context. It showed that 63 % of the users liked the look & feel as well the usability.

Nineteen percent said that that the look & feel should be improved and 13 % stated that the usability should be improved. Regarding the quality of the search results, the performance and the fun factor of the widgets, 38 % of the users said these issues were in need of improvement. Forty-four percent rated the quality of the search results as good, the performance got a good grade from 50 % of the users, the fun factor was rated as good by 38 % and even as outstanding by 13 % (Fig. 4).

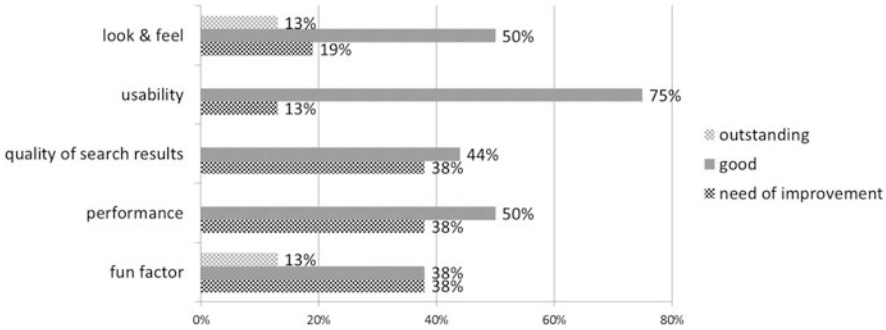

Fig. 4 The first impression of the prototypes

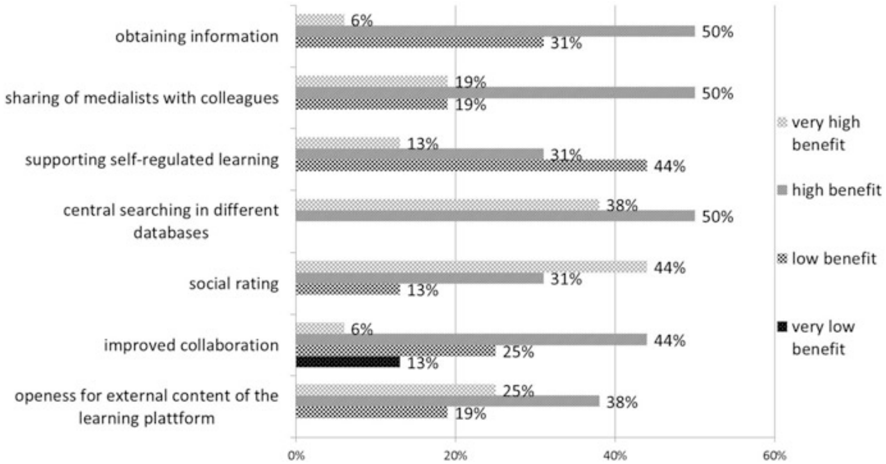

Fig. 5 Perceived usefulness of the prototypes

Evaluation of the benefits of the prototypes showed that most of the users saw a high or very high benefit of the offered tools. The highlights regarding the benefits were in this case the federated search feature over several knowledge resources. Fifty percent stated a benefit and as many as 38 % stated a high benefit. For the rating feature 31 % stated a benefit and as many as 44 % stated a high benefit. The good overall impression of the evaluation reflects especially in the recommendation value—in total 88 % of the test users would recommend the tools to their colleagues. Last but not least, perceived usefulness and effectiveness was evaluated with the question "do you think the offered services will help you to work more effectively in your job then at present?" Thirty-one percent fully agreed, 50 % agreed and only 6 % denied that they would be more effective when working with these tools. This was a really good result for this early prototype evaluation from Festo's point of view (Fig. 5).

The Second Evaluation Loop

The subject of the second evaluation loop was the PLMS prototype, which was developed with the goal of integrating the approaches of the LMSs and the PLEs, and thus of supporting the user during SRL. The evaluation was conducted on a PLMS prototype, which was integrated into an IMC test environment.

The acceptance of the learning environment was and is an essential aspect in this regard. In particular, if an introduction of training offers, which will be used on a voluntary basis, is concerned, it is important for the training provider to determine the acceptability extend of the learners. Thus, the objective of the evaluation was to find out how well the PLMS was accepted by the employees, and which measures could be implemented to further increase its acceptance.

The following usability factors were important:

- The selection and addition of widgets, and navigation learning spaces
- The use of resources, such as wizard widgets and tutorials
- Acceptance of the PLMS
- Handling of the PLMS
- Comparisons with conventional training media and forms of learning

Therefore, several methods were used in order to evaluate the PLMS. Observation was conducted on the one hand, and the so-called “think aloud” or “question asking” method was used on the other. In addition, the questionnaire entitled “Perceived Usefulness and Ease of Use” was used in this evaluation supplementing data obtained by means of observation and the “think aloud method” (“TAM”). For reasons of comparability, the questionnaire was developed within the framework of the ROLE project, which was intended to ascertain usefulness and user-friendliness of the project results as perceived by the learner. It was also used in other test beds.

The “TAM” was used as a supplementary method in addition to observation. In particular, this method was used for examinations of the user interface because it is especially well suited for detecting problems of this sort. With the use of “TAM”, the thought processes of the learners were investigated while they were dealing with the PLMS.

Test persons were prompted to describe their actions and thoughts out-loud during interaction with the learning environment. In this way, the test persons were not only able to address any problems they were experiencing with the user interface, they could also explain them and, as a result, could reveal design defects. Furthermore, the test persons expressed thoughts of satisfaction, enthusiasm or motivation when commenting on their actions. Thus, data compiled by means of “TAM” provided in-depth knowledge, not only regarding the actions of the test persons, but also about their attitudes as well. If applicable, information about their experiences gained in dealing with the software, could also be gathered.

The “TAM” was used in a slightly modified form, which was more comparable to an interview technique, by means of which the study director asked the user targeted questions regarding comprehension, the sequence of the learning activities, etc. This counteracted the danger that the test person talked less and less while working with the learning environment, and no longer remembered to comment on his actions out loud. This problem might have occurred because working with the PLMS represented a very new and complex task, for which the user required a large portion of his cognitive capacity.

The evaluation supervisor spoke with the test persons or helped them work through the learning steps in the PLMS, if requested to do so. However, this influenced the experiences, the attitudes and the actions of the learners. This influencing factor was taken into consideration in the evaluation of the results. As a rule, "TAM" was conducted with help of audio or video recordings. Instead of a reconstructive form of data collection, "TAM" made use of so-called registrative data conservation. This simplified evaluation and assured the reliability and validity of the compiled data. "TAM", thus, effectively compensated the weaknesses of participative observation.

Evaluation Procedure

During the evaluation phase 11 interviews were conducted with employees of the Festo Learning Centre. The employees came from different departments and had different educational backgrounds. The evaluation was allotted a duration of 45–60 min per test person. The users were requested to complete a task in the PLMS to this end. Subsequently, the test persons evaluated the PLMS with regard to acceptance, system performance, required effort and user-friendliness, as well as use of and satisfaction with the application assistance.

The survey "Perceived Usefulness and Ease of Use" consisted of two parts. Those questions which were considered as learning premise, namely those regarding age, sex and TEL experiences were presented before the PLMS test. The other part of the survey dealing with the evaluation of the product, in this case the PLMS, was conducted after the PLMS test.

The evaluation supervisor was available while the questionnaire was being filled out, and was able to help the test persons with any questions or uncertainties. However, the test persons were initially only asked to respond to the closed questions. Then the observation started, during which time the observer took notes. If it was needed and time allowed it, the observer went deeper with the open question section in order to clear up any unanswered points.

Results

The evaluation of the questionnaire entitled "Perceived Usefulness and Ease of Use", provided the following summary: Eighty-one percent of test persons rated the learning environment PLMS as useful. Fifty-five percent indicated that they would achieve their learning goals somewhat more effectively with such a learning environment. The usefulness of the learning environment was rated diversity.

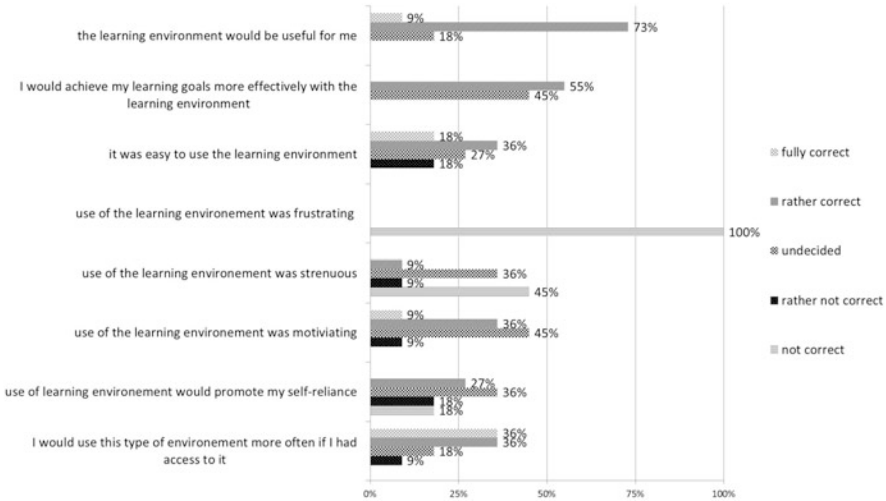

Fig. 6 Results of the questionnaire “Perceived Usefulness and Ease of Use”

Eighteen percent chose “fully correct” and 36 % rather correct while 27 % were undecided and 18 % said that the uses were rather not easy.

There was a strong agreement with 100 % that the use of the learning environment was not frustrating. But the evaluation showed that there was still a need for improvement. Almost half of the interviewees (45 %) said the use of the learning environment was strenuous or rather strenuous. However, the vast majority with 72 % of the respondents would use or rather use the learning environment, while only 9 % said that they rather not use the tested learning technology. The results in details were shown in the Fig. 6.

Further, through the use of the “TAM” it was possible to document positive as well as negative statements of the probands. Figure 7 represents a compendium of the most important statements, divided into the categories effort, performance and facilitation.

In conclusion, the evaluation results of the PLMS allowed the following statements:

– The use of the PLMS is deemed highly beneficial
– The PLMS supports the achievement of individual learning goals
– The PLMS would be used by the learners, if access to a tool was available
– Usability, as well as the look and feel of the PLMS prototypes, must be greatly improved

In terms of challenges, however, some technical hurdles appeared regarding the usability as well as look and feel of the PLMS for future implementations. These challenges related to specific computer-based issues and are all undergoing further investigation.

Statements from the thinking aloud interviews		
How user-friendly are the PLMS and the integrated widgets? **(effort)**	Are performance and functions recognised and appreciated? **(performance)**	How well supported does the learner feel within the learning environment? **(facilitation)**
Positive: • Hardly any problems adding the widgets • Breakdown into steps promotes clarity **Room for improvement:** • Confusion upon exiting the PLMS and entering the browser • Usability of many of the widgets is faulty • The monitor is frequently overloaded with scroll bars	**Positive:** • Media lists facilitate research on the Internet **Room for improvement::** • Creation of private media lists would be desirable • Create an option for integrating well-known tools • Conventional storage media are given precedence	**Positive:** • Demo video is indispensable **Room for improvement:** • Video for the "Learn" phase is too long • Content of the wizard is not understandable at first glance • Help questions, tips and recommended tool categories do not provide enough help • It's frequently unclear when the individual learning phases are completed

Fig. 7 Statements from the thinking aloud interviews

Nonetheless the feedback from the evaluation investigation remains very positive. It appears that people really liked the PLMS approach. Additionally, and since the test phases took place, albeit on a prototype, the interviewees asked also for refinements of the system in relation to their user experience.

Conclusion and Outlook

The Future of TEL in Business Context

The ROLE approach and the gained experience showed the potential of TEL solutions not only in the higher education field, but also in business context. This sounds quite simple at first, but it is extremely important. Higher education settings and learning at a company are not two different worlds, but completely different learning scenarios, with different learning goals and needs, different learners, different learning conditions and learning possibilities. Often in research projects initial solutions are presented without entirely knowing the specific surrounding conditions.

But these kinds of solutions are more innovative than useful. There are a lot of hurdles and specifications in companies according to organisational, technical and personnel requirements. Therefore, it is important for TEL researchers to start every TEL activity with a target group-specific requirement analysis and after this to transfer the acquired scientific developments into these new learning environments.

On the other hand, for bigger companies it is important to be open to new ideas, opportunities and learning approaches as that can help to identify, share and archive important knowledge in a better or additional way than before. Often a big revolution is not necessary. Companies have a lot of different learning technologies and learning possibilities that are, however, separate, internal closed systems without synchronisation and different responsible departments and responsible persons. Thus, these learning technologies are in internal and in external competition with one another and a systematic integration of technology-enhanced learning tools is a challenge.

During the ROLE project, Festo has used its chance to learn from the ROLE-consortium and bring new research results together with specific business requirements. During the project the Virtual Academy was opened up through enhancing CLIX by OpenSocial widgets. The different evaluation loops showed that is not only a current trend move away from closed LMS to more self-regulated and individualised learning. Rather, it confirmed the first impression of the project team to combine the advantages of the existing LMS with the PLE approach. One outcome of this approach was the Festo LearningTube which enables every Festo employee to produce and share user (expert) generated learning videos on the LMS.

The good thing is not only the received Comenius award but also the fact that it is possible to share very easily user generated content in a company now. The knowledge carriers produce their content on a voluntary basis without the necessity of additional incentives. This supported Festo significantly in improving this learning environment with the developed technologies and the intelligent combination of formal and informal learning.

What Are the Next Steps?

The Virtual Academy, especially the LearningTube will be continuously improved. In this context three topics will be more and more important:

- Learning analytics
- e-Learning goes mobile
- Full text search in videos

Learning analytics is a very interesting field for Festo in terms of learning transfer analysis. Researching how this process can be taken beyond the step of e-tests and e-evaluation is a specific interest of Festo. Just in time analysis of user data, visualising learning processes to users, context aware services and individual recommendations based on learning goals or learning needs would be one of the future scenarios.

When Festo started with the Virtual Academy it was only accessible via the Intranet, so people could only learn from their workplaces. This was considered as a bottleneck for the learning processes, so the platform was moved on a server that is also accessible via the Internet. The goal is to make use of the benefits of e-learning especially learning independent from time and location. This step, taken in 2005, can be taken even beyond by bringing content also to mobile devices such as mobile phones and tablets. This opportunity should be realised as soon as possible, especially because the demand of the learners for mobile learning services is continuously growing. A big lever for this approach is that the videos from the

LearningTube are mobile compliant and can therefore be easily "consumed" from mobile devices.

Video-based learning is more and more an essential source of knowledge and information in companies. As described before, the Festo LearningTube is a rapidly growing internal video portal. At present there are more than 220 expert generated videos and more are being produced every day. Unfortunately the search function is not yet as developed. The growing number of videos results in a growing need for state of the art search functionalities to support learners as much as possible find the learning content they need. The objective is to find a solution that efficiently combines voice recognition with the videos on the Virtual Academy and make them thereby "full text searchable".

Conclusion

The ROLE philosophy of Festo was to open the existing Virtual Academy LMS and extend it with new technologies supporting individualisation of the learning process and increasing its efficiency. The LMS and PLE approaches were combined towards a PLMS fulfilling existing business requirements. This was technically realised by means of integration of the PLE elements into the LMS platform and pedagogically with the use of SRL method. As previously described, the first step was to implement two widgets (media search and media list widgets) in the existing Festo Virtual Academy LMS. At the second step, this approach was extended and realised as a PLMS supporting four learning phases of the SRL process (plan-search-learn-reflect).

The use of the PLMS at workplace supports, on the one hand, curriculum-based learning allowing completing learning programmes and courses created by an organisation for its employees. On the other hand, it extends usual personnel development measures with SRL activities giving the employees an opportunity to specialise in the most important and interesting fields of knowledge, thus, developing their competencies and skills in an individualised manner addressing personal strengths and preferences. This assures gaining of obligatory knowledge and skills for completing specific tasks by the employees and supports personal development, thus removing borders between workplace and spare time learning.

Moreover, while using the PLMS SRL competencies, such as goal setting, planning, time management, resources search, and self-evaluation, are trained. These skills can be applied by the learners not only in training context but also at the workplace helping to improve every-day working processes and achieving better results. Festo sees the need to support learners with the new technology and to develop SRL and media competence as key factors for successful working with the PLMS and the ROLE technologies. In this development process Festo keeps in mind that, in a business context, there are complex requirements and restrictions, for example, the contrasts between:

– Openness versus data security (e.g. the work council, the data protection officer and some others had very different opinions and views on the proposed work)
– Companies' targets versus individual targets
– Implementation strategy: the "Revolution" (completely new technology) versus the "Evolution" (successive further development of existing tools)

The conclusion, therefore, is that the current vision and deployment of a PLE towards an integrated PLMS implementation with predefined learning spaces on the technical side seems to have been warmly welcomed. Nonetheless, from the psycho-pedagogical perspective it remains essential that learners are able to learn in a self-regulated manner.

The required technical improvements, therefore, have to be synchronised with the necessary individual development of specific SRL competences in order to meet these very real needs. The bigger pedagogical challenge, however, will be to promote the new approach to learners on a large scale. The evidence that this is possible is the fact that the LearningTube widget bundle has become an essential part of the Virtual Academy.

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Lessons Learned from the Development of the ROLE PLE Framework

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Abstract Within the ROLE European research project, an interoperability framework has been developed to support self-regulated learning and to enable learners and teachers to create personal learning environments (PLEs). This framework enables learners to assemble tools, services and resources together to create their own custom learning environment. This chapter discusses the overall architecture, the specific components of this architecture and the platforms in which we have integrated the ROLE framework. Additionally, we share the lessons learned from the design and development. Furthermore, we discuss our experience with the

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ROLE development infrastructure and our collaboration within the ROLE development team and with several open-source projects.

Keywords Development • Interoperability • Best practices • Lessons learned • Collaboration • Open source • Widgets • Web apps • Framework • Personal learning environment • PLE • Informal learning • Self-regulated learning • Social media platforms

Introduction

The proliferation of Web 2.0 technologies (e.g. wikis and social networks) has impacted the way users retrieve and use information and how they interact with each other (Maness 2006; Ullrich et al. 2008; Ashley et al. 2009). The abundance of Web-based tools and content creates many opportunities for Technology Enhanced Learning (TEL).

The ROLE project aims to exploit Web-based tools and technologies to empower learners to construct their own personal learning environments (PLEs). The overall goal is to create flexible, Web-based, open technologies for the federation and mash-up of learning services to empower the learner to build her own responsive learning environment. Responsiveness is defined as the ability to react to the learner needs—i.e. through recommendation, adaptation or visual analytics services that support the learner to be aware of and reflect upon her own learning process (Fruhmann et al. 2010). The project also targets critical transition stages of lifelong learning, e.g. due to shifts in learner interests or when leaving the university and entering a company. Chapter 1 elaborates more on the ROLE vision on PLEs.

Learning management systems (LMSs) such as Moodle, CLIX and Blackboard primarily focus on distributing learning content, organising the learning process and serving as interface between learners and teachers. Dalsgaard (n.d.) notes that in LMSs generally different tools, such as discussion forums, file sharing, whiteboards and e-portfolios, are integrated in a single system that bundles all tools necessary to manage and run courses. In contrast to PLEs, LMSs place a strong emphasis on how to centralise and standardise the learning experience (Guo et al. 2010). Learning activities in an LMS-based course are organised within a centrally managed system, which is driven by the needs of the institution. On the other hand, a PLE takes a more natural and learner-centric approach and is characterised by the free-form use of a set of services and tools that are controlled and selected by individual learners.

In recent years, research on mash-ups has been elaborated, for example widget mash-ups have been deployed at Graz University of Technology (Ebner and Taraghi 2010). In addition, researchers have focused on augmenting traditional LMSs with widgets to provide live-updating and flexible applications. Wilson et al. (2009) have implemented widget support for Moodle. Their big challenge is logging student activities with the widgets, as there is no communication between the widgets and the LMS.

The ROLE framework builds on this existing work, but incorporates additional core technologies such as inter-widget communication (IWC), automated user activity tracking, collaborative spaces and authentication and authorisation services to protect data. This is the basis to enable real-time communication between widgets and users, and to automate user activity tracking from tools and services. The analysis of such data and IWC provides the basis to develop responsive systems that can react to learner needs in a coordinated way.

Within the time span of the ROLE project, a new Apache project, called RAVE,[1] emerged with the aim to provide an extensible mash-up platform for using, integrating and hosting widgets with personalisation, collaboration and content integration features. The features of Apache RAVE and the ROLE project are quite similar, as confirmed by recent research that has been applying RAVE in educational contexts (Pierce et al. 2011; Chudnovskyy et al. 2012). Since the RAVE project started during the development of the ROLE framework, ROLE did not adopt Rave, but rather contributed components to the RAVE project (which is discussed in more detail in section 'Contributing ROLE Software to Open-Source Projects').

This chapter presents the ROLE interoperability framework, which is a technical platform to assemble widgets within responsive open learning environments. The framework allows the assembly of widget bundles with communication channels, authentication and authorisation mechanisms and services for activity tracking and analysis. The framework ensures that the widgets have access to the necessary information to react to learner needs. Furthermore, the platforms, on which the interoperability framework has been integrated, are discussed and the lessons learned from the design and development of the framework components are presented, as well as on the technical collaboration within the ROLE project and with open-source projects.

This chapter is organised as follows. First, the overall architecture of the framework is presented in section 'The Interoperability Framework', after which each component is discussed in more detail. Section 'ROLE Platforms' elaborates on the different platforms that integrate the ROLE infrastructure and the repository of widgets. Afterwards, the organisation of the ROLE developer community and our contributions to open-source projects are discussed. Finally, the achieved results are summarised and their dissemination is discussed.

The Interoperability Framework

The purpose of the ROLE interoperability framework is to support assembly of different widgets in responsive open learning environments. The architecture supports communication between widgets, authentication and authorisation

[1] Apache RAVE, http://rave.apache.org/

mechanisms, services for activity tracking and analysis and widget spaces, which manage widgets, resources and users. All these services can be accessed via open and if possible standardised interfaces. These are necessary for third-party developers who want to create applications based on ROLE technology. The next section details the overall architecture.

The Architecture

The ROLE architecture is illustrated in Fig. 1. IWC (see section ‘Inter-widget Communication’) is used and managed by spaces, but is also an autonomous component. It depends on JavaScript and the XMPP (Saint-Andre 2004a, b) protocol to provide a user-, community- and space-centred remote IWC. This allows developers to build powerful collaborative real-time learning tools and learners to assemble them easily in responsive open learning environments.

Tracking of activities is done via the Contextualised Attention Metadata (CAM) framework (see section ‘Contextualised Attention Metadata’). An event-based schema was developed to model user behaviour in learning environments. Events are tracked and sent to either a central or container-specific repository. IWC is used to track such events. The data is stored and retrieved via an REST API.

As the CAM service contains sensitive data, an authorisation and authentication framework has been developed to protect this data (see section ‘Authentication and Authorisation’). It is also needed for other ROLE services that handle personalised data. One of the main goals of this framework is to reduce the amount of user interaction by providing a Single Sign On (SSO) authentication mechanism.

Finally, widget spaces (see section ‘Spaces’) allow learners and instructors to create portable collaborative learning environments. Spaces consist of learners, configurable services and sharable resources, within a learning context. The space features can be provided either by a (OpenSocial) container itself or by a special widget. Such an approach guarantees container independence. Furthermore, widget

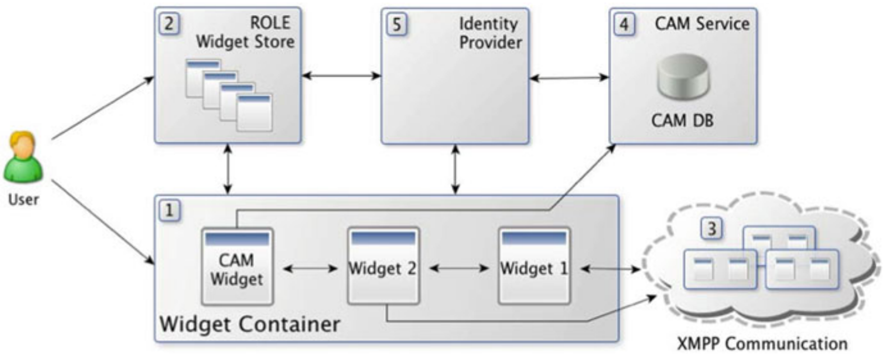

Fig. 1 The ROLE architecture

spaces provide a simplified single point of access to the other background services via an extended OpenSocial API.

Inter-widget Communication

IWC enables event-based communication between widgets following the Publish–Subscribe communication pattern (Birman and Joseph 1987; Eugster et al. 2003). We employ both local inter-widget communication (LIWC) within a PLE and remote inter-widget communication (RIWC) among different users, computers and PLEs.

LIWC is realised in the OpenApplication Event API (Isaksson and Palmer 2010, n.d.) using the HTML5 Web Messaging standard (Hickson 2011) available in most major browsers, including backwards compatibility for the Google Gadget PubSub mechanism. Instead of 'hard-wiring' widgets with each other (Sire et al. 2009), all widgets within a PLE are notified of all events and then decide autonomously to react accordingly. If the widget acts upon the received event, a receipt is sent back. Supporting containers that receive such a receipt can inform the user, e.g. by highlighting the tool that sent the receipt. The event payload format is designed for partial semantic interoperability, i.e. developers use a combination of established vocabularies in a simplified format with name-spaced properties (e.g. Dublin Core (DCMI Usage Board 2006)). In practice, this means that when an event is broadcasted, the originating widget does not indicate what receiving widgets should do (only the past action is specified, e.g. select). If the originating widget had to specify the intent (i.e. the desired future action), it would need to have buttons or menu items for every conceivable proposable action in every conceivable widget (e.g. add to portfolio, share with friends, search in Wikipedia). With events, we instead choose to split the job: events should be broadcasted for as many user actions as possible within each widget, without concern for what receiving widgets ought to do, and receiving widgets provide the affordances (e.g. buttons) for their own proposed further actions.

RIWC enables communication among widgets in different browsers and on different machines in order to foster real-time remote communication and collaboration functionality. RIWC is realised with the Extensible Messaging and Presence Protocol (XMPP) (Saint-Andre 2004a, b), an open standard for real-time communication. The power of XMPP lies in its built-in federation capabilities and extensibility through XMPP Extension Protocols (XEPs), such as for Publish/Subscribe (Millard et al. 2010) and Multi-User Chat (Saint-Andre 2008) as applied in responsive and collaborative learning scenarios (Friedrich et al. 2011). Since no JavaScript XMPP library with PubSub support was available, ROLE extended the dojo XMPP library by a set of common PubSub operations. Users can discover nodes, retrieve subscriptions, create, configure and delete nodes, subscribe and unsubscribe nodes and publish/receive IWC events in an XML-based payload format across a federated network of XMPP servers. However, current libraries using XMPP over BOSH (Paterson et al. 2010) are not applicable in public containers such as iGoogle due to cross-domain issues. Furthermore, they are rather unstable and unreliable (Friedrich et al. 2011). Our experiments showed that the upcoming Web Socket API (Hickson 2009) for XMPP (Moffit and Cestari 2010) outperforms BOSH with considerable performance and stability improvements and availability in all containers.

IWC enables more responsive, collaborative environments with real-time notifications and richer user experience, although attention to usability is required (Isaksson and Palmer 2010).

Contextualised Attention Metadata

Tracking of user interactions with widgets is an essential part to enable responsiveness in learning environments. User interaction data can be used for data analysis and the computation of personal, social and contextual information about users and applications. Additionally, such data of the actual usage of ROLE services in real-world settings was used to evaluate the framework.

A variety of attention metadata formats exist. These formats differ in scope, expressiveness, scalability and context awareness. Butoianu et al. (2010) provide a survey of the following formats: TaskTracer (Dragunov et al. 2005), Swish (Oliver et al. 2006), CAM (Wolpers et al. 2006), the User Interaction Context Model (UICO) (Rath et al. 2009), the Context Modelling Language (CML) (Henricksen and Indulska 2006) and WildCAT (David and Ledoux 2005). TaskTracer and Swish are least flexible and expressive. UICO, CML and WildCAT are very expressive; however, the available frameworks using the formats do not scale well and some are focused on a specific application (Butoianu et al. 2010). On the other hand, CAM supports scalability and context awareness very well, but is less expressive. Other examples are the ActivityStreams specification[2] and the Experience API (Glahn 2013). The latter took inspiration from ActivityStreams and only became available in the last years of the ROLE project. ActivityStreams are less focused on contextual information. In ROLE, CAM is used because of scalability and context awareness.

The CAM schema (Schmitz et al. 2011) can be used to describe computer-related activities of one or several users—i.e. which objects attract user attention, which actions users perform and what the user contexts are. CAM was developed to describe as many types of attention metadata as possible. Therefore, CAM records of a user cannot merely describe user foci of attention, but rather her entire computer usage behaviour. Collections of CAM records can be exploited for generating diverse kinds of profiles like user profiles and object profiles (item profiles). CAM records represent user–computer-related foci of attention and actions and thus can instantly constitute profiles of individual usage behaviour.

[2] The ActivityStreams specification, http://activitystrea.ms/specs/json/1.0/

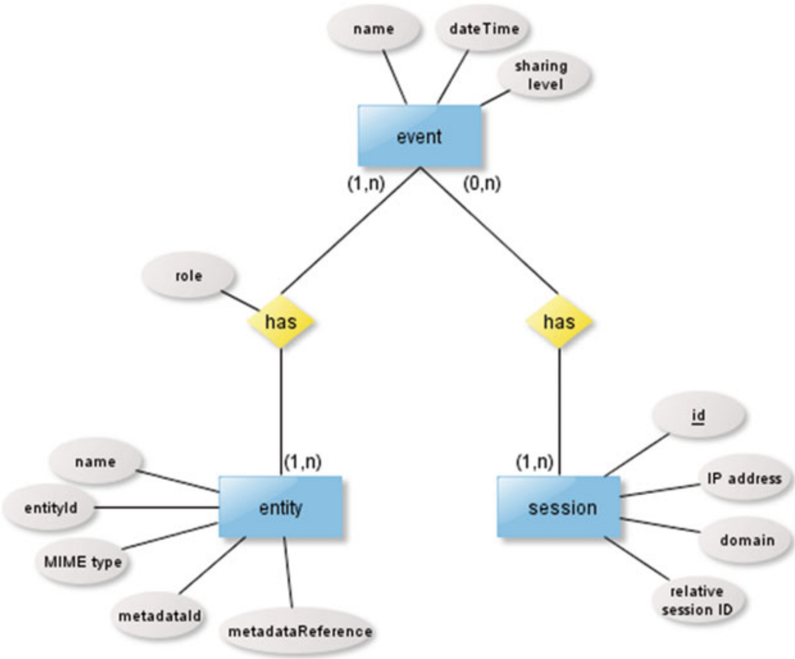

Fig. 2 Structure of the CAM schema

CAM records of different users can be exploited for generating attention and usage-based object profiles.

CAM records can be used to support self-reflection. For instance, visualisation widgets can support a user to recapitulate what she did and generate a picture of her competences. Furthermore, statistical metrics can be employed to aggregate and evaluate CAM records of different users. By this, general trends, for instance in computer usage, data consumption and communication behaviour, can be detected. Aggregated CAM records entail information on the behaviour of average users and on the behaviour of user groups. They also entail usage information on data objects, such as how often a certain object was used, and by which kinds of users and in what contexts it was used. In addition, they can reveal in which respect a user deviates from the average, whether her behaviour conforms to general trends or not, etc.

The CAM schema has been developed to provide a unified schema for monitoring data across system boundaries (Wolpers et al. 2007; Schmitz et al. 2011). The CAM schema has been transformed from a once user-centred version to an event-based version (see Fig. 2) that is better suited for evaluating and analysing user observations over time.[3]

[3] Information about the schema is available at https://sites.google.com/site/camschema/ and the CAM API: http://sourceforge.net/projects/camapi/

One major goal of ROLE is to provide personalisation, recommendation and self-reflection mechanisms. To achieve this, users can be monitored while interacting with their learning environment. The collected CAM information is used to generate different patterns and statistics, such as discovering learning trends and detecting what is currently happening in the learning environment. For an easy integration of the CAM monitoring into different learning environments, the monitoring architecture was divided into a client and a server component. The client component can be considered as a data collection element, responsible for accumulating and transforming the information into CAM, while the server component is responsible for the persistence management and data access control.

Figure 3 shows the CAM architecture applied in ROLE and how it works together with other ROLE components. The picture shows a platform, which uses ROLE technology by integrating ROLE widgets into their learning environment

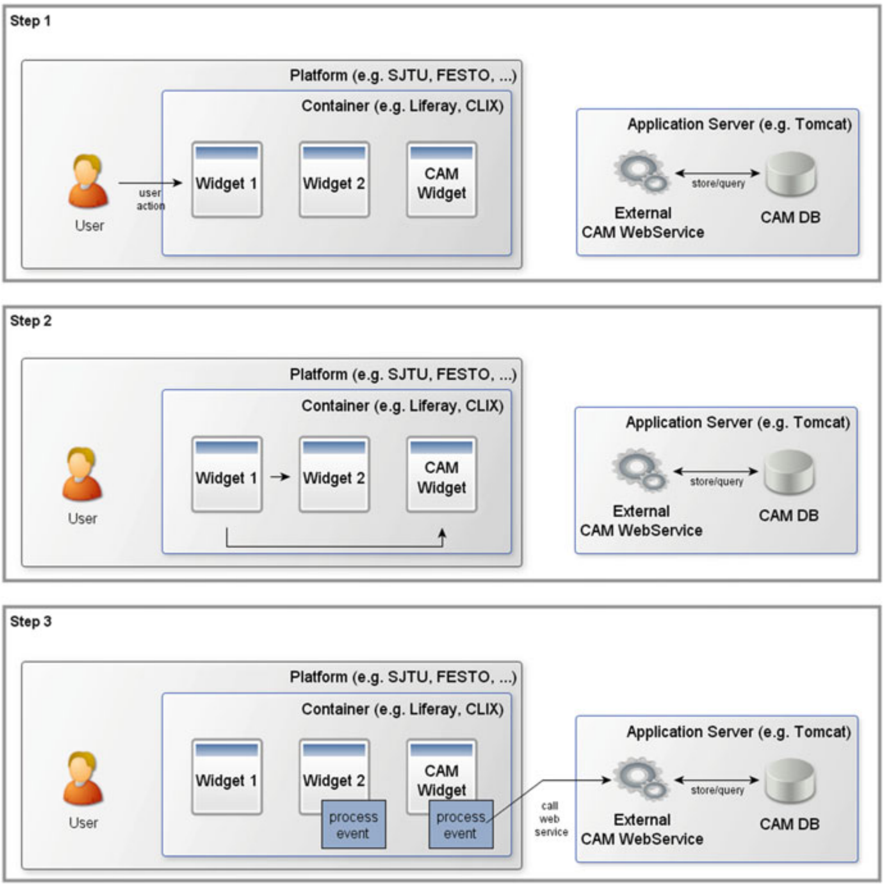

Fig. 3 The CAM architecture used in ROLE

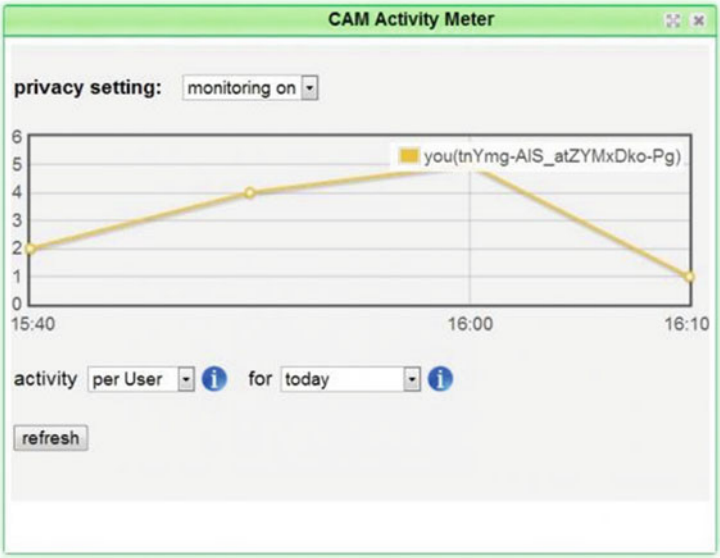

Fig. 4 Screenshot of the ROLE CAM Monitoring widget

(container). Furthermore, the picture illustrates that the CAM monitoring components must not be integrated into the platform since they are running on an external application server. First, a user performs an action on a widget (step 1), e.g. clicking a button. Since this widget supports IWC (see section 'Inter-widget Communication') this action causes an event, which is published via the OpenApp mechanism (Isaksson and Palmer 2010; Isaksson and Palmer n.d.). Thus the event is broadcasted (step 2) and can be received by all other widgets in the user's learning environment (local IWC, see section 'Inter-widget Communication'). Each receiving widget can process and react on the event (step 3). The CAM widget can thus receive all events sent through IWC. Afterwards the CAM widget identifies the event and forwards all required information to the CAM Web service, which is responsible for the CAM mapping and persistence. To offer the user an overview over the activities in the learning space, it contains a graph where past events from the users of the space can be displayed using different configurations, i.e. one or several users and several dates (see Fig. 4). As already mentioned, the picture illustrates that the Web service is not integrated into the platform, but is a standalone service that can be installed for a specific platform.

In addition to storage, the CAM Web service provides a query method, which consumes an arbitrary SQL select statement and returns the results in the JSON format. Using arbitrary SQL select statements ensures maximum freedom for the developers to experiment with the data. Access to the monitoring data causes privacy issues. These issues have not been completely resolved in the ROLE project. Some steps have been taken though. For instance, data privacy can be supported through a stand-alone installation of the CAM Web service, e.g. by installing the CAM service in the intranet of an institution. The CAM widget also allows users to disable tracking (see Fig. 4). Additionally, the CAM Edit and Share widget[4] (see Fig. 5) allows the user to filter and export her CAM data from a specific space into an SQL file. This widget provides the user with full access and larger control over her CAM records, and she can share her events with others or analyse them herself. Finally, since the Web methods for querying and storing CAM are publicly available, the CAM service requires password-based authentication.

From our experience developing the CAM service and using it in real-world settings various new insights have been gained. One of the main benefits of the approach is that developers do not have to specifically write code to track user events, as the CAM widget will collect the IWC events automatically. On the other hand, this can also limit the data collection since not all important events might be requiring IWC. This tracking method also allows developers to be agnostic about the CAM schema and the implementation of the CAM Web service, since they do just need to send out IWC events. One of the strengths of the OpenApp IWC is the openness of its data format, which has no mandatory fields and enables developers to transmit any kind of JSON data from one widget to another. This freedom makes the mapping of the OpenApp events into CAM harder as such mapping cannot rely on certain elements to be present. Defining a subset of fixed mandatory IWC fields and fixing taxonomies of event types would make the CAM mapping more easy and robust.

Another flexibility issue is due to the high abstraction level of the CAM schema to allow all kind of events to be stored. This can generate a large number of different CAM event mappings, which can make it harder to analyse and compare the CAM records. The different IWC events stored information in different CAM fields, making the data analysis more complex without knowing the details of the intrinsic mapping. The ActivityStreams specification provides an extensible, common vocabulary list of actions that would aid this and when applied properly could provide more portable data (Vozniuk et al. 2013).

Currently, user activities are only tracked when the CAM widget is added to the learning environment. Hence, this enables users to have full control over where their activities are tracked, but also causes that nothing is recorded if the user forgets to add the CAM widget. This problem could be circumvented by integrating CAM monitoring directly into the platform.

[4] http://www.role-widgetstore.eu/tool/cam-edit-and-share-widget

Fig. 5 Screenshot of the ROLE CAM Edit and Share widget

Spaces

In the ROLE framework, a PLE can consist of various spaces. A space is an abstract concept that materialises the user's context and aggregates people, resources, applications and other subspaces. All these artefacts belong to the same activity that a person (or a group of them) is working on to achieve a common goal. This common goal is the purpose to create the space. Various people can participate in a space and might have different access rights and roles within this space, where they share resources and applications that they need to achieve their goal. A space might have subspaces that help hierarchical organisation of resources, applications and people. A space can be seen as a PLE unit. On the one hand, a space is a way for users to give shape to their PLEs by aggregating information. On the other hand, a space allows users to share their PLEs with others by inviting them to collaborate.

The space concept exists in all ROLE platforms (see section 'ROLE Platforms'): the ROLE SDK (see section 'ROLE SDK'), Graasp[5] (Bogdanov et al. 2012a) (see section 'Graasp'), the OpenSocial Moodle plugin (Bogdanov et al. 2012b) (see section 'OpenSocial Moodle Plugin') and the Widget Store (see section 'The ROLE Widget Store'). Every platform internally implements this concept in a different way. In order to allow widgets to use the information about the space and to enable integration and portability of spaces between the platforms and beyond, we applied two approaches: Linked Data and OpenSocial.

For the first approach, we created a space ontology for Linked Data. Linked Data provides a very powerful and extensible way of describing data in a machine-understandable way. It targets the discovery and integration of data originating from different sources. Due to its design, it has limitations. First, Linked Data and SPARQL require a rather steep learning curve, which is a disadvantage compared to simple RESTful APIs that are used by many Web developers.[6] The second limitation is the performance. Since the data is located on different servers, many HTTP requests have to be issued to retrieve the complete data. Moreover, the SPARQL engine requires traversal of a graph, which is much slower than retrieving data from a relational database. The authors Health and Bizer (n.d.) (see section 6.3) foresee the use of data crawling for real-time Linked Data applications, rather than on-the-fly URI dereferencing.

The alternative approach we used is OpenSocial. The OpenSocial specification consists of three main parts. The first part describes the widget standard. The second part standardises the model for social network elements (i.e. Person, App and Document) and relations between them. The third part standardises a set of common REST and JavaScript APIs to retrieve data from a social platform. Since the space concept did not exist in OpenSocial, we introduced it into the OpenSocial specification. The OpenSocial Space extension standardises the space model (namely a list of fields that a space can contain), and the REST and JavaScript

[5] Graasp, http://graasp.epfl.ch

[6] Linked Data API, http://code.google.com/p/linked-data-api/wiki/API_Rationale

APIs to work with spaces (Bogdanov et al. 2011). Through this extension, widgets can retrieve information about their containing space and its content via OpenSocial APIs. For example, the Person API can be used to retrieve all the members of the space. The widget can retrieve a list of the resources and widgets available in the space via the Document and App APIs, respectively.

The main disadvantage of OpenSocial is that the social model cannot be easily and arbitrarily extended as with Linked Data. The new extensions require going through the process of standardisation, which can be quite cumbersome. On a positive note, OpenSocial provides easy-to-use REST APIs with a JSON-based data representation. The data format and APIs are standardised, which enables interoperability when data is accessed and processed. OpenSocial does not target data discovery (as Linked Data) but rather data retrieval and exchange. Since the data is often centralised in one institution, it is very fast to retrieve the data compared to the SPARQL engine.

Authentication and Authorisation

CAM contains sensitive and personal data protected by law. Additionally, users might prefer to keep the content of their spaces private. The data access has to be trusted and allowed by the users. The data communication occurs at two different levels: service-to-service and widget-to-service communication.

Service-to-service communication can occur when for example a recommendation service requires CAM relevance feedback on resources. Data can be transferred across institutions and countries with different laws. Thus, we decided to leave the decision of service-to-service authentication and authorisation (A&A) up to the service developers.

Widget-to-service communication occurs when for example a self-reflection widget wants to query the CAM service. This has been implemented as follows. A user is authenticated as being the owner of a particular personal space. The user first authenticates as being the owner of a separate identity, to which the personal space is linked (or a new personal space will be created), which thereby implies that the user is the authenticated owner of the space. The personal space then functions as the identity of the user.[7] Authentication is typically done via OpenID, which is the standard for decentralised authentication on which we have focused, but other protocols may be supported as well (one test bed, at Uppsala University, has implemented support for CAS while also keeping support for OpenID authentication).

Delegated authorisation is used by widgets that access collaborative and personal spaces. Furthermore, such delegated authorisation may also be used by third-

[7] The identifier of the personal space, i.e. a URI, is used as the identifier of the user, cf. WebID (see http://www.w3.org/wiki/WebID)

party services. The standard for delegated authorisation that we have focused on, i.e. OAuth, lets the currently authenticated user choose whether to authorise the widget or service. After authorisation, the service is provided with a token granting access to spaces on the user's behalf. For widgets, the token is managed by the OpenSocial widget container, which allows widgets to perform requests through the engine's OAuth proxy that first applies OAuth and then forwards the request.

Currently, OAuth endpoints for OpenSocial widgets must be hard coded in the widget's source XML. Therefore, spaces implement a rewriting of the XML so that the proper endpoints are included. Otherwise, it would be necessary for widget developers to maintain separate XML files of their widgets for every server where the widget is deployed. Widgets using the rewritten XML files, however, can be added to any widget container, such as Liferay[8] (Yuan 2009), while still maintaining the connection to their respective spaces.

ROLE Platforms

The ROLE interoperability framework has been integrated in various platforms. This section describes these platforms where users create and use their PLEs and search for widgets.

The ROLE SDK

The ROLE SDK is a collection of software and tools, which allows trying out ROLE technology and developing new widgets for mash-up PLEs. In total, ten versions of the ROLE SDK were released, each one packaging the implementation outcomes of one milestone of an iterative development process (see section 'The ROLE Developer Community').

The central core of the SDK is the reference implementation of a sample PLE, which allows using ROLE technology in practice and developing new widgets at the same time. Within the ROLE SDK, a learning space functions as a collaborative context for learning, consisting of a bundle of widgets, along with a list of participants. Widgets can interact with other widgets, and participants can interact with other participants, by using widgets and built-in features of the ROLE SDK (e.g. chat functionality).

A personal space is defined as a personal context that consists of a person's user model. One representation of the user model is a user profile; another representation, also based on the user model, is a bundle of (personally chosen) widgets. In the

[8] Liferay, http://www.liferay.com/

ROLE SDK, the learning space and personal space are combined in one user interface.

Additionally, there is a social context. The social context offers access to the communities of which the user is a member. The specific community that is accessed typically depends on the website where the widget is currently being used, which may be a different website than that of the PLE. For instance, if a widget is being used on a social networking website, the community would be that of the website. Collaborative contexts (i.e. learning spaces) can transcend social contexts. A widget may be part of a learning space, and at the same time be used on a social network for inviting people from that network to participate in the space. OpenSocial standardises APIs for access to what is defined as the social context here.

Furthermore, the concept of activities was introduced. Activities can be defined as purposes for which the user structures her learning context and assembles widgets. In the ROLE SDK, activities are displayed as one group of visible widgets at a time. In the GUI, activities can also be tabs or pages. However in the ROLE SDK, the additional semantics that the term ‘activities’ offers is covered. The term hints to the user that the groupings should be used for focusing on one activity at a time (such as training English vocabulary or searching for Web resources), using the tools that are appropriate to that activity, without being distracted by what is unrelated to the activity.

As mentioned before, the ROLE SDK relies on the concept of spaces. While a space is, at its most basic level, simply a bundle of resources such as widgets, there are several aspects that contribute to its usefulness as the basis for a PLE:

- *Aggregation*: Widgets (or more generically, tools) are bundled with any other kind of resources that contribute to the space’s goals. The model enables a very flexible use of spaces, without requiring modifications in the model or its implementation.
- *Contextualisation*: A space forms a context for its contained resources. Widgets can be made context aware, and are then able to interact with the space and its resources. In addition to being in the context of a space, widgets can be contextualised further by being given configuration that is specific to their instantiation within the space.
- *Participation*: People can join a space, which means that they become members of that space. Members are notified of the presence of other members, and can interact with them both asynchronously and synchronously.
- *Personalisation*: Spaces offer a level of customisability, so that users are able to personalise the environment according to their needs.

These design requirements are realised within the ROLE SDK. Being a sample implementation of a PLE platform, the space user interface (see Fig. 6) is a Web application composed of four parts. First and on top, the header element is implemented as a top-aligned bar. It provides elements for controlling the Web application as a whole, such as signing in and out, and navigating to other parts of the application. Secondly, the sidebar element is a narrow, fixed-width section,

Fig. 6 The ROLE SDK user interface of a learning space

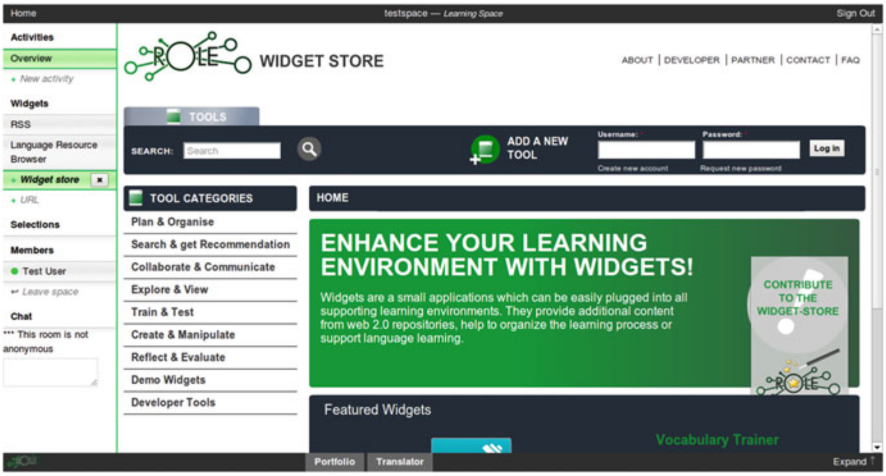

Fig. 7 The ROLE Widget Store, embedded in the ROLE SDK

running along the left side. It provides elements for controlling the space, such as switching between activities, and adding widgets.

Thirdly, the container element comprises the central area of the user interface, not covered by the other parts. This is where the main content is located, typically the space's widgets. The container can also be used as an embedded browser, which is how the ROLE Widget Store (see section 'The ROLE Widget Store') is integrated (see Fig. 7).

The fourth and last element is the dashboard, a bottom-aligned bar when collapsed. Expanding the dashboard displays the widgets on the personal space

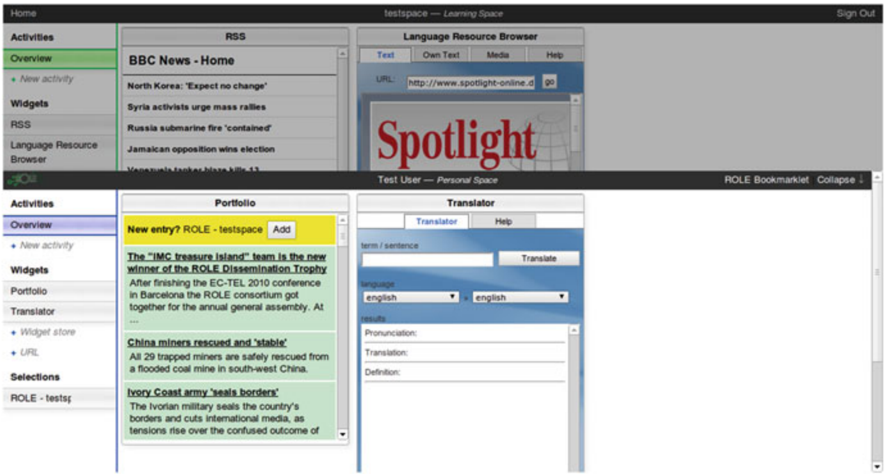

Fig. 8 The personal space, inside the expanded dashboard

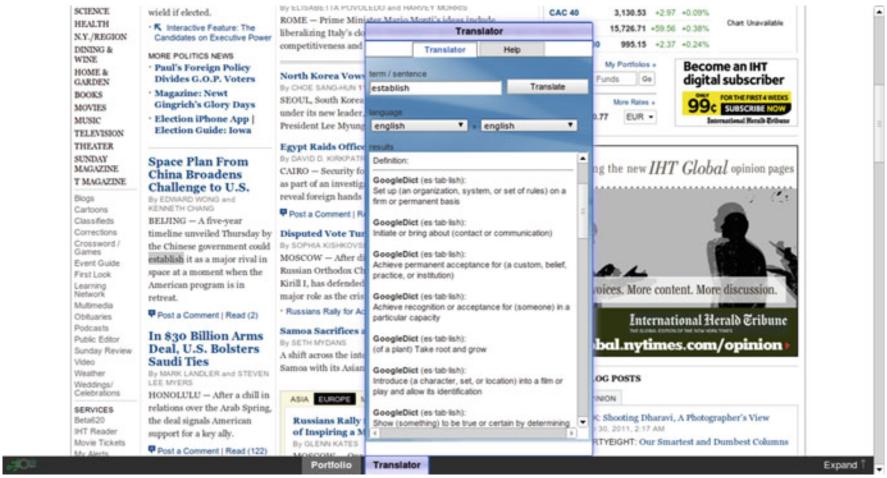

Fig. 9 The personal space, being accessed on a third-party website

right above the container, as illustrated in Fig. 8. The dashboard provides access to the user's personal space, which is a space that is private to the authenticated user. It is available from any other space (and other pages of the Web application) as well as from third-party websites via a bookmarklet (cf. Fig. 9).

In the case that the space itself is embedded (e.g. on the course page of an LMS), it is intended that the parts can be hidden or moved (e.g. the Header), because their functionality (e.g. sign in) can be already provided by the LMS or to adhere to another design.

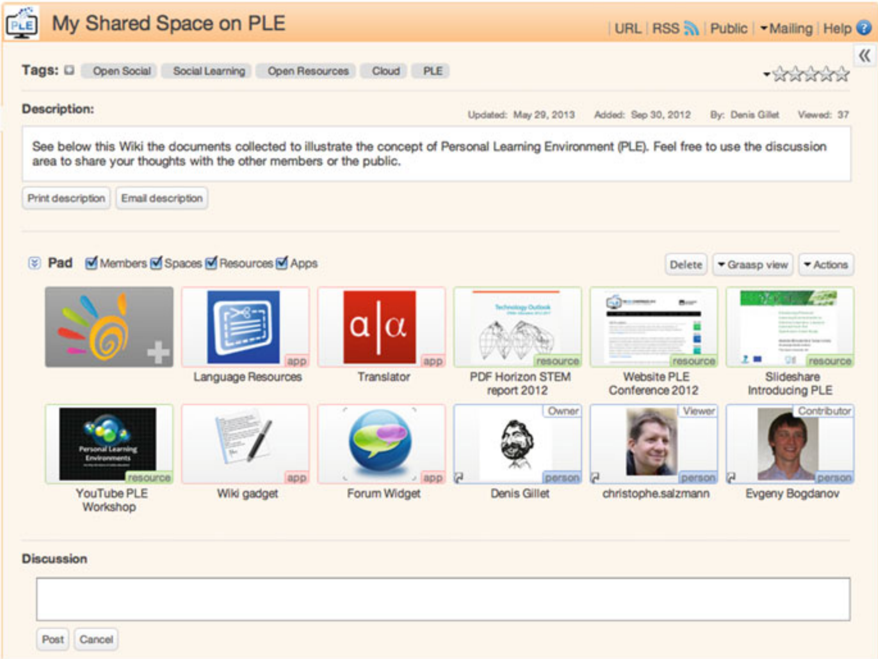

Fig. 10 A shared contextual space created in Graasp that integrates resources gathered from the Cloud, such as YouTube videos, SlideShare presentations, OpenSocial Widgets, Web pages or PDF documents with previews

Graasp

Graasp[9] (Bogdanov et al. 2012a) is a social media platform for collaborative learning and knowledge management (see Fig. 10). Graasp implements the OpenSocial space specification (see section 'Spaces'), which enables the creation of spaces shared between people belonging to different communities and networks. Embedded shared resources are gathered across institutional and corporate boundaries. Unlike dominant social media, Graasp enables a fine definition of the audience, as well as the associated rights and roles to ensure trust and privacy enforcement. In Graasp, people map their personal and shared projects, interests and activities into public or private contextual spaces integrating invited members, relevant resources and necessary apps which can be tagged and rated. Any space or resource in Graasp integrates its own discussion thread to enable contextual interaction. Graasp allows learners to construct and manage their own PLEs. Users can create a PLE for each learning objective, populate it with various resources and tools, personalise it and share it with others (Bogdanov et al. 2012a).

[9] Graasp, http://graasp.epfl.ch

The space concept is at the core of Graasp. A space can represent a PLE and can contain four types of entities: people, resources aggregated and used within the space, apps added to the space to extend its functionality and subspaces to organise the space content in a hierarchical structure. Graasp enables users to manage their spaces.

The resources and apps can be aggregated into a Graasp space from both local and remote locations. First, users can easily drag and drop files directly from their desktops into their spaces. Second, remote resources from the Cloud can be easily aggregated via an aggregation mechanism called GraaspIt!. Whenever a user encounters an interesting page, she can simply click on the GraaspIt! bookmarklet in the browser and the resource will be added into a space (Gillet and Bogdanov 2012). These collected resources can be aggregated as URLs, embed tags or Web page screenshots. In addition to resources, Graasp allows users to aggregate widgets into their spaces. Currently, the OpenSocial widget standard is supported, though other standards (e.g. W3C widgets) can be added in a similar way. Such widgets either can be added manually or can be aggregated from existing widget repositories. For example, when the user is browsing through widgets in a widget repository (e.g. the ROLE Widget Store, see section 'The ROLE Widget Store'), a widget of interest can be added by just clicking on GraaspIt!. The second way is to add widgets from the ROLE Widget Store by exploiting the widget repository search mechanism provided within Graasp.

Once a space is created and populated in Graasp, the core part of the interface (see Fig. 10) enables users to interact with the aggregated content and can be further personalised with the concept of functional skins (Bogdanov et al. 2011). A functional skin is a client-side plugin for a space that can retrieve space data via the OpenSocial APIs and provides users with visual and functional features different from Graasp and tailored to specific needs. For example, in addition to the standard view of Fig. 10, Graasp offers two built-in functional skins: the resource view and the app view. The resource view displays a list of all resources that exist in a space and provides download links and presents resource previews. The app view displays all widget instances from a space as a visual mash-up. In this view, widgets can be resized and their order can be modified through drag and drop. The possibilities to personalise the space are extensive and through functional skins the users can further adapt their spaces for their own professional/personal tasks.

Graasp implements several mechanisms to share and exchange spaces and widget bundles (sets of widgets combined together for a specific purpose). An app bundle can be extracted from the existing space and exported as an OMDL file.[10] The OMDL file can be imported into another platform (or reused in Graasp) or shared at the ROLE Widget Store. Additionally, a space created in Graasp can be shared with other people and with other platforms. The space can be extracted from Graasp as a secret URL. This URL can be given to other users and allows them to collaborate anonymously. Alternatively, the space can also be embedded into

[10] Open Mashup Description Language, http://omdl.org

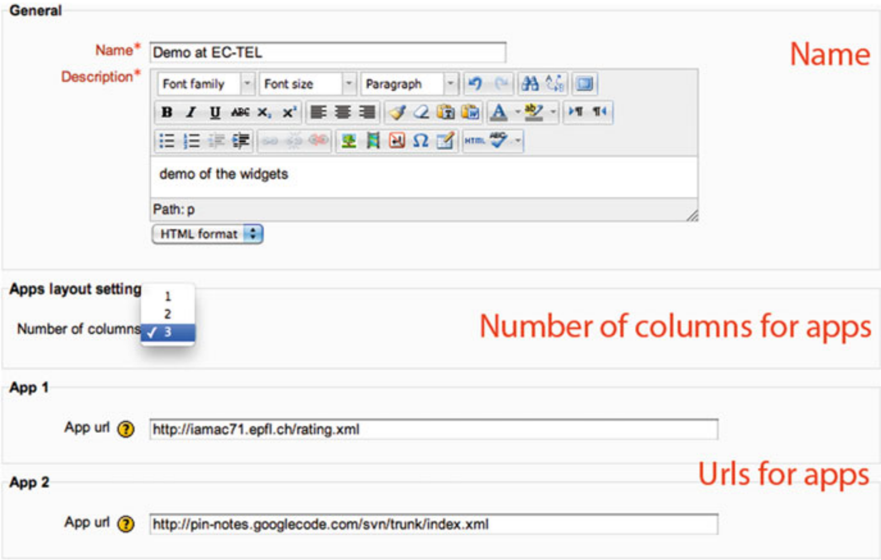

Fig. 11 A teacher creates a space with widgets for a course

another Web platform. Chapter 5 provides more information on how Graasp was used and evaluated for formal learning.

OpenSocial Moodle Plugin

The OpenSocial Moodle plugin (Bogdanov et al. 2012b) enables the use of OpenSocial widgets within the Moodle LMS[11] to create PLEs. By providing support for PLEs in an existing LMS, the disruption often caused by providing users with completely new environments decreases. By integrating PLE features in an existing LMS, users can still continue to use the features of the familiar LMS, but can personalise their learning environment with widgets.

The OpenSocial plugin for Moodle exists in two variations. The first version adds a new module to Moodle, which is displayed in the central area in the Moodle UI.[12] The module allows a teacher to add a 'widget space' to the Moodle course page, specify a set of widgets and choose the widget layout on the Moodle page (see Fig. 11). After this configuration, students can work with several widgets simultaneously (see Fig. 12) in the Moodle course.

[11] Moodle, http://www.moodle.org

[12] OpenSocial Moodle module, https://github.com/vohtaski/shindig-moodle-mod

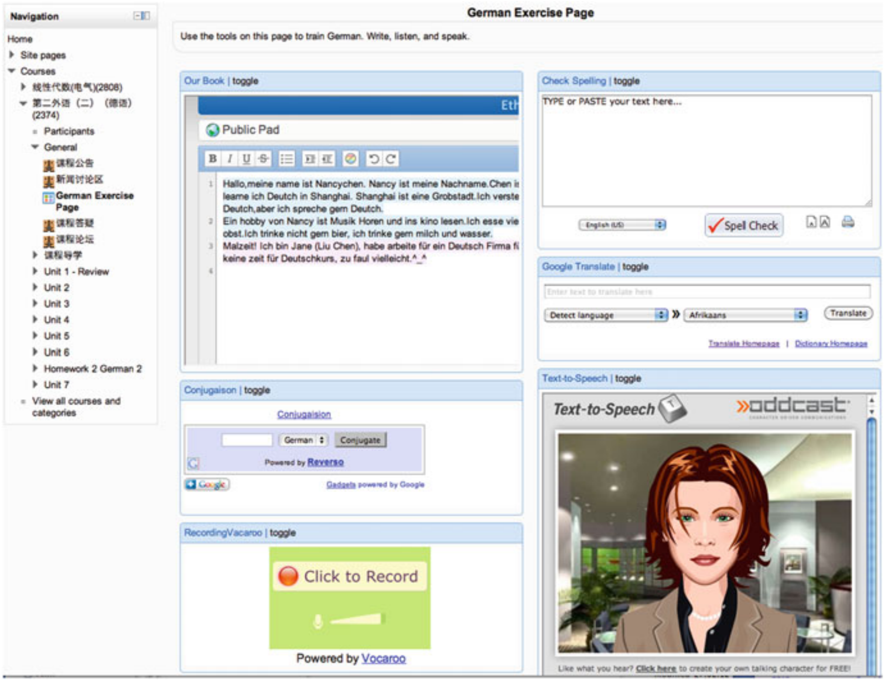

Fig. 12 OpenSocial widgets displayed within Moodle

The second version[13] of the OpenSocial plugin adds a new block in the right column of the Moodle UI. With this Moodle block, the teacher can add widgets to the right column of existing Moodle pages. Both versions of the Moodle plugin make use of the Apache Shindig engine,[14] which provides an open-source implementation of the OpenSocial specification, to render and manage widgets.

One of the main benefits of these plugins is that they enable teachers to easily extend Moodle with new features and services provided by widgets. Consequently, once the OpenSocial plugin is installed in Moodle, a teacher can append the required functionality herself, without the intervention of system administrators. The plugin enables the flexibility of selecting the resources and tools required for a specific course. Additionally, the plugins enable reuse of existing educational resources and tools. Furthermore, teachers and students can continue to operate in the learning environments they are familiar with but gain the mash-up features of PLEs. Naturally, the components of the ROLE architecture are compatible with the Moodle plugin. For instance, IWC and CAM are fully operational in the Moodle plugin. By extending widely used LMS with PLE features, we aim to achieve a faster adoption of the PLE paradigm among institutions. Further details on how this

[13] OpenSocial Moodle block, https://github.com/vohtaski/shindig-moodle-block

[14] Apache Shindig, http://shindig.apache.org

Moodle plugin was put to use for formal learning and evaluated are available in Chap. 4.

The ROLE Widget Store

The ROLE Widget Store allows users to search and browse for widgets and compilations of them. The store addresses the issue of categorisation, browsing, searching and recommending by providing various widgets categorised based on functionality, learning phases and learning domains. Further, the Widget Store enables sharing of platform-independent PLE and templates composed of learning tools and artefacts (or the so-called Widget Bundles). Via these mechanisms, the Widget Store fosters the development of a community of practice to exchange learning tools. Regarding the widget bundles, the store provides features to apply and share bundles across different learning platforms. This section further discusses different recommendation strategies and the interfaces that enable interoperability are specified (LMS/PLE system integration). Figure 13 presents an overview of the Widget Store architecture.

The main focus of the store is to provide a catalogue of widgets by supporting two commonly used widget specifications: the W3C widget specification (Caceres n.d.) and the OpenSocial specification (Mitchell-Wong et al. 2007). Developers can post either their self-developed widgets or widgets based on licenses which allow further distribution. Where possible metadata are automatically extracted from the

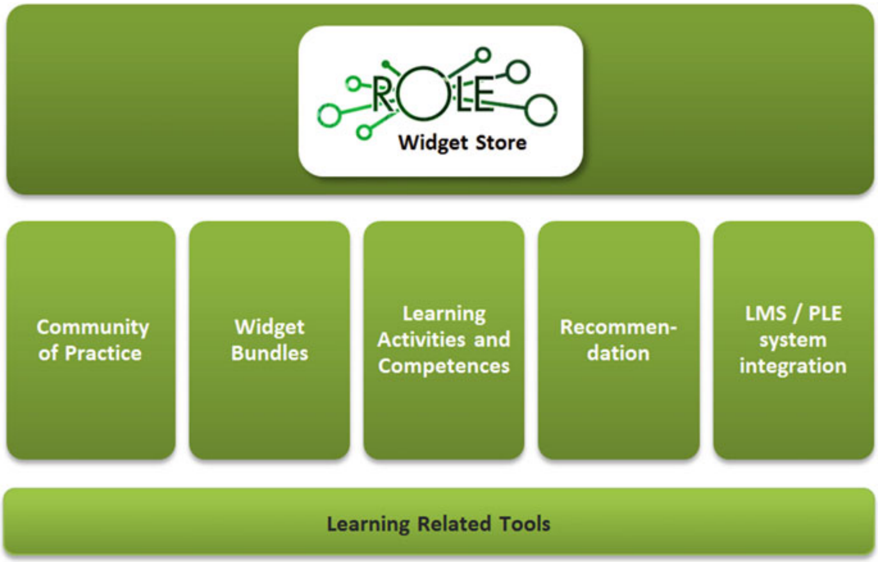

Fig. 13 Components of the ROLE Widget Store

widgets. Widget bundles are compilations of widgets, which are created to share good practices of widget use in learning environments. They are intended as a fast and simple way to provide learners with tools, services, content and a detailed description of how to use these to complete a specific learning task. Learners can select several tools from the store to create their learning environment. Additional references to learning resources can be added. For each tool and resource, learners are able to add learning activities in order to describe what should be done using the tool or learning resource. Once such a bundle is created by a learner, she can share it with the community. Such bundles can be reused by teachers and learners for their learning environments. In order to support learners in selecting applications for their PLEs three different categorisations are provided.

- Tool categories are derived from the Psycho-Pedagogical Integration Model (PPIM) (Fruhmann et al. 2010) (more information on PPIM is also available in Chap. 2), so users can select widgets supporting different learning phases.
- Tool functionalities represent features of widgets (e.g. text editing, video chat) and are based on an ontology developed in ROLE.
- Learning domains describe, if possible, the domain of the tools by providing semantic tags using DBpedia.[15]

The categorisation of bundles differs from the tool categorisation. A bundle can be designed to cover several phases of the PPIM model and thus refers to several tool categories. The approach of the Widget Store is that a bundle automatically inherits functionalities of tools it contains and can be tagged manually by learning domains from the DBpedia.

To provide an interface for external systems, the ROLE Widget Store offers an SPARQL endpoint which allows retrieval and insertion of the data of the Widget Store based on a standardised interface. Furthermore, different formats (Turtle, RDF/XML and JSON) are supported so that developers can choose their preferred data format. Another possibility for PLE platforms to integrate the store is to embed the store in the learning environment. The embedded version provides a simplified user interface and offers buttons that allow users to directly choose widgets to assemble their PLE. The store is connected to other ROLE components in the following ways:

- Graasp queries the store to provide a catalogue of widgets enabling easy integration of widgets in Graasp spaces.
- The ROLE SDK embeds the store and uses the embedding features to add widgets to the ROLE spaces.
- The ROLE Pedagogical Recommender (Nussbaumer et al. 2012) queries the store to provide recommendations based on the ontology of learning activities and the store categorisations.

[15] DBPedia, http://dbpedia.org/

- The ROLE Requirement Bazaar[16] (Renzel et al. 2013) uses the data to support the requirements elicitation and negotiation process being part of the ROLE Social Requirements Engineering approach. The ROLE Requirement Bazaar is a collaborative social platform where users can illicit their needs and wishes to developers who can extract requirements for future implementation.

Widgets and Tools

One major problem regarding the adoption of ROLE in new test beds and increasing the number of users was the limited number of widgets that were available.

One approach to overcome this problem is to enable a very simple transformation of existing Web resources into widgets (Ullrich et al. 2013). This transformation can be done by developers through the usage of widget templates as well as by non-technical people with the help of an authoring tool. Both solutions support the same ROLE technologies, namely the capturing of interactions via CAM and the possibility to rate the widgets. Interactions are captured on a very generic level: basically, whenever a student uses a Web application integrated into a widget for a period longer than five seconds, then the widget sends out CAM event of the type 'used'. Of course, a developer can refine the interactions, when required.

The 'widgetisation' of a Web application is simplified through the usage of a template and through JavaScript libraries that can be included in (existing) widgets. The template defines a widget that embeds the Web application via the iframe HTML element. This has the advantage that the original Web application does not need to be modified. In case, a widget of the Web application already exists, the capturing of interactions via ROLE can be enabled by the inclusion of the JavaScript library. This library uses IWC to send out the captured interactions, which can be made persistent on the CAM service via the CAM Monitor widget as described in section 'Contextualised Attention Metadata'.

The proposed approach has been implemented and a widget template is available in which the widget developers have to add the link to the Web page they want to integrate. To extend an existing widget, one has to include several lines of JavaScript code. The generation can be automated by using a set of shell scripts. The scripts take a list of URIs as input and generate widgets for the URIs. This reduces the authoring time to less than a minute. In summary, while this solution works very well for advanced software developers, it is still too complex for the average user. As an example, the code to extend an existing widget with ROLE technologies looks as follows:

[16] ROLE Requirements Bazaar, http://role-is.dbis.rwth-aachen.de:9090/BazaarFrontend/index.html

```
//Load two libraries for allowing the user to rate this gadget//and for
capturing interactions in CAM format $.getScript("http://widgets.
onlinesjtu.com/gadgets/libs/rating.js",

  function(){
    $.getScript(
  "http://widgets.onlinesjtu.com/gadgets/libs/interactioncapture.
js",
     function(){
      var rating = new ROLE_module.rating
                  ("#importedGadget");
       var interactioncapture =
        new ROLE_module.interactioncapture
               ("#importedGadget");
       })
   }
);
```

The first lines load the libraries. The functionality is activated by creating the appropriate objects. In the example, #importedGadget specifies the HTML element to which the interaction capturing and rating functionality should be attached (typically a div element, which is the parent of the iframe element).

In addition to the simplification of the usage of the libraries, the Shanghai Jiao Tong University (SJTU) created an authoring widget that allows teachers without Web development expertise to generate widgets from existing Web resources. The authoring widget asks users to input the URI of the Web application and add some metadata. Then, the authoring tool generates and uploads the widget to a server. Through an integration with the OpenSocial Moodle module (see section 'OpenSocial Moodle Plugin') users can create widgets without having to leave the learning environment.

Thanks to these tools, SJTU was able to create several hundreds of very domain-specific widgets for ROLE. Additional details on the SJTU test bed are presented in Chap. 4.

ROLE and Open-Source Developer Communities

All technical partners of the ROLE project have been collaborating successfully to create the ROLE framework. To foster this collaboration, various support mechanisms were set up, consisting of management structures, sub-projects, development software and developer meetings. This section elaborates on the developer collaboration within the ROLE project and with open-source projects to disseminate ROLE technologies.

The ROLE Developer Community

Technical cluster structure: To enable the assessment of requirements, exploration of technologies, creation of early prototypes and their evaluation, the development process was split up in consecutive sub-projects, each having its specific goals and deadlines. In total there were five of such projects: the Christmas project (ended on Christmas 2010), the Easter project (ended on Easter 2011), the Stonehenge project (ended on December 22, 2011), the Gunpowder project (ended on January 31, 2012) and the Shori project (ended on January 31, 2013). By defining use cases and goals for each project, the requirements and planning were defined. These projects also allowed easier planning of evaluations. The longer projects (i.e. the Gunpowder and Shori project) had a more elaborate planning phase and management methodology. For the Gunpowder and Shori project we aimed to apply the SCRUM (Schwaber 2004) and Kanban (Ladas 2009) methodology. But due to the large, geographically dispersed team from different organisations, we opted for an adapted version of SCRUM combined with Kanban, where one or two persons would manage the development process and report progress to the ROLE general assembly. The requirements and goals for the projects were often laid out in a face-to-face developer meeting or developer camps (see below) and follow-up virtual meetings. The project managers would then plan milestones (or sprints) often based on evaluation deadlines and showcases at conferences. Certain topics had smaller teams working on it in task forces, e.g. assessing a solution for authentication or CAM. Bi-weekly technical virtual meetings were organised to discuss progress, and to decide on technology and architecture choices. This setup allowed all developers to work on their own tasks and be involved in the decision making, but also get an overview of the current project status. Furthermore, it allowed the project managers to follow up the progress and react quickly where needed. This approach was received positive by developers, managers and general assembly. Next to this methodology, the development was also assisted by software.

Development software: To support the developers and the management, several software packages were set up. To provide access to and version control our source code we experimented with Git[17] and Subversion (SVN).[18] Initially, Git on GitHub[19] was used, but at that time GitHub did not fulfil the requirements of the project. To reduce the complexity, the source code was migrated to Subversion.[20] At the end of the project, the source code was migrated again to GitHub,[21] since GitHub has a more flexible scheme where any external developer can reuse the source code without any intervention from the repository owner. Whereas

[17] Git, http://git-scm.com/

[18] Subversion, http://subversion.tigris.org/

[19] GitHub, https://github.com/

[20] The Subversion repository is available on Sourceforge at http://sourceforge.net/projects/role-project/

[21] The ROLE GitHub repository is available at https://github.com/organizations/ROLE

Sourceforge still requires management by a ROLE partner. To manage the projects, milestones and bug and issue tracking, Atlassian JIRA[22] was used. Tasks, feature requests and issues were collected in JIRA and assigned to projects and milestones. Open tasks and issues were discussed in the technical meetings. Overall, our JIRA experience was quite positive, as it enabled a quick overview of the progress and future work for developers and managers. Clearly, to have a consistent and up-to-date overview, developers have to be committed to report their work in JIRA.

Developer camps: During the project period, three developer camps were organised. Originally, the developer camps were meant for internal developers to discuss the overall ROLE architecture and technical solutions, and plan the projects. During the first developer camp, a shared vision of the ROLE objectives was created. At the second and third developer camp, external experts were invited to provide feedback on the architecture, identify missing use cases and requirements and provide a broader scope on recent research results that could be applied in ROLE. At the third developer camp (November 2011), we invited a larger group of experts, presented the current status of the ROLE framework and had a small developer competition to develop widgets for the platform. This was only possible at this time, because the implementation was mature enough. This developer competition was good both for dissemination to research and open-source projects (e.g. Apache RAVE), and for getting feedback from external developers on the ROLE APIs and documentation. Later we organised four more widget competitions that were open to the public. In general, the developer camps were a good platform to collaborate with the whole ROLE technical team and external experts for a couple of days.

Contributing ROLE Software to Open-Source Projects

Several components and specifications of the ROLE framework were integrated in other open-source projects. This strategy enables further uptake and development of the research results of the ROLE project. This section highlights some of the contributions to the open-source community.

OpenSocial and Apache Shindig: In order to standardise the OpenSocial space extension (see section ‘Spaces’), EPFL worked with the OpenSocial community for the specification and with the Apache Shindig community for the reference implementation of the specification. The communication with both communities happens through mailing lists. After our specification proposal was presented on the mailing list, it received very positive feedback and representatives of several companies showed interest in the extension for use in their products. After several discussions and refinements of the proposal, the work on the specification draft started. Typically, the procedure to get a proposal accepted is as follows: First, a patch to the

[22] Atlassian JIRA, http://www.atlassian.com/software/jira

OpenSocial specification has to be written. Second, the proposal has to be implemented in an open source, publicly available platform, e.g. Apache Shindig. Finally, when the proposal is finalised, the community votes on the final inclusion of the draft into the specification. Consequently, ROLE wrote a patch for the OpenSocial specification and extended Apache Shindig, which was shared with the OpenSocial community.

When we started our proposal, the OpenSocial community was finalising OpenSocial version 2.0. Thus, initially our proposal would be incorporated in the next version, 2.5. However, later the decision of the community was to have only limited changes in 2.5 and leave all larger revisions for the upcoming version 3.0. Hence, due to the large changes that our proposal would cause, it was decided to postpone its inclusion and it was only incubated in OpenSocial 2.5. Because of other changes in the specification of OpenSocial 3.0, our proposal had to be adapted. Eventually, the process that seemed open and efficient turned out to be quite time-consuming. Currently (December, 2013), the proposal is still on the road map for the OpenSocial 3.0. The patch for the specification is ready and the code for Apache Shindig is available. Once the work on the OpenSocial 3.0 is started, the patch should be evaluated and voted upon final inclusion into the newest version of the specification.

However, adding a proposal into the specification does not immediately guarantee that it can be used in all OpenSocial platforms. To be able to use the space proposal in widgets and to enable interoperability with other OpenSocial platforms, all platforms have to implement the latest version of the specification. There can be latency, since it takes time to upgrade to newer versions of OpenSocial.

Apache Rave: As mentioned in the introduction section, Apache RAVE is an open-source mash-up platform with similar functionality as the ROLE framework. Therefore, it was a very interesting project to contribute to. Technical ROLE partners have joined two Apache RAVE Hackathons in the Netherlands to present our work and discuss collaboration. The RAVE community received our concepts and implementation enthusiastically. Their main interest was in our IWC component, the space concept and our Linked Data-based APIs to retrieve and store data in the PLE. As the space specification proposal was already submitted to the OpenSocial community, ROLE decided to propose the two other components to the RAVE community. The process to achieve this is quite similar to the OpenSocial procedure. One has to announce the idea on the public mailing list of Apache Rave, where the idea and its specification can be openly discussed. The next phase is to provide an implementation of the component in RAVE and submit a patch. This patch will be reviewed by the community and after acceptance can be included in upcoming milestones. At the time of writing, both proposals have not yet been accepted. We hope to get approval of the RAVE community in the near future.

Strophe.js: The parts of the IWC component have been contributed to the open-source JavaScript XMPP library, named Strophe.js.[23] We mainly contributed our implementation of the XMPP protocol over WebSockets.[24] This makes the library more efficient as data can be efficiently pushed from server to client and long polling is no longer necessary.

Discussion and Conclusion

This chapter presented the architecture of the ROLE framework and the platforms where this framework has been integrated. The ROLE framework provides several components to enable responsive open PLEs, such as IWC, automated user activity tracking, collaborative spaces and authentication and authorisation services to protect data. These components provide the basis for real-time communication between widgets and users and automatic user activity tracking from tools and services. To evaluate the usability and usefulness of the ROLE philosophy and the ROLE framework, we have integrated the ROLE framework in various platforms, such as Moodle, CLIX (Govaerts et al. 2011; Rensing et al. 2013), Graasp and the ROLE SDK. These platforms have been used in various real-world evaluation settings (Govaerts et al. 2011), which have been documented in Chaps. 4, 5, 6 and 7.

In general, we can conclude that with the ROLE framework we were able to meet the project requirements and support the test beds. The birth of the Apache RAVE project with very similar goals indicates the interest and usefulness of the ROLE philosophy. Furthermore, the framework produced several components that were of interest to other open-source projects. Some of these open-source contributions have been completed, while others are still in progress. Additionally, results of the ROLE framework will be reused and extended in other research projects. For instance, the ROLE Widget Store will be reused in the Go-Lab project[25] as a repository of apps and online laboratories to enable teachers to assemble learning environments with online laboratories for inquiry-based learning. Additionally, Go-Lab will also use Graasp and the OpenSocial Spaces specification to enable inquiry-based learning spaces for STEM education at school. On the other hand, researchers of the Learning Layers project[26] are using and extending the ROLE SDK as their learning platform (Kovachev et al. 2013). As mentioned, the ROLE SDK is mainly meant for developers to extend their existing learning environments

[23] Strophe.js, http://strophe.im/strophejs/

[24] WebSocket, http://www.websocket.org/

[25] Go-Lab, http://www.go-lab-project.eu/

[26] Learning Layers, http://learning-layers.eu/

or extend the ROLE SDK itself to support their requirements. To support this, developers can easily contribute or fork the ROLE SDK GitHub repository.[27] We hope that in this way large parts of our efforts will be used beyond the end of the ROLE project.

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Commentary

The following sections offer the comments of experts outside of the ROLE project consortium about the contents of this book. Each expert was asked to review and comment upon a chapter of this book that is relevant to their expertise, thus offering their feedback about a certain aspect of the ROLE research outcomes.

Personal Learning Environments, Self-Directed Learning and Context

Graham Attwell

Research and development in learning technologies is a fast moving field. Ideas and trends emerge, peak and die away as attention moves to the latest new thing. At the time of writing MOOCs dominate the discourse. Yet the developments around Personal Learning Environments (PLEs) have not gone away. It could be argued that the development and adoption of PLEs is not so much driven the educational technology community but by the way people (and not just students) are using technology for learning in their everyday lives.

Even when Learning Management Systems were in their prime, there was evidence of serious issues in their use. Teachers tended to use such environments as an extended file storage system; forums and discussion spaces were frequently under populated. In other words such systems were used for managing learning, rather than for learning itself. Learners expropriated and adapted consumer and productivity applications for their learning. Such trends became more pronounced with the emergence of Web 2.0 and social software. Social networking applications in particular, allowed the development of personal learning networks. Rather than go to the institutionally sanctioned LMS or VLE, learners communicated through

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Facebook or Whats App. PLNs were not longer limited to class or course cohorts but encompassed wider social and learning networks. Wikipedia has emerged as a major open resource for learning.

As mobile technologies have become increasingly powerful and, at least in some countries, internet access has become increasingly ubiquitous, learners use their own devices for learning and are not confined to institutional facilities. Regardless of trends in educational technology theory and research, learners are developing and using their own PLEs.

At the same time, the ongoing rapid developments in technologies are changing forms of knowledge development and leading to pressures for lifelong learning. Universities and educational institutions can no longer preserve a monopoly on knowledge. Notwithstanding their continuing hold on accreditation, institutions are no longer the only providers of learning, a move seen in the heart-searching by universities as to their mission and role.

Such changes are reflected in the growing movement towards open learning, be it in the form of MOOCs or in the increasing availability of Open Educational Resources. The popularity of MOOCs has revealed a vast pent up demand for learning and at least in the form of the c-MOOCs has speeded the adoption of PLEs. MOOCs are in their infancy and we can expect the rapid emergence of other forms of open learning or open education in the next few years.

Learning is becoming multi-episodic, with people moving in and out of courses and programmes. More importantly the forms and sources of learning are increasingly varied with people combining participation in face-to-face courses, online and blended learning programmes and self-directed and peer supported learning using different Internet technologies.

These changes are reflected in discussion over pedagogy and digital literacies. It is no longer enough to be computer literate. Learners need to be able to direct and manage their own learning, formal and informal, regardless of form and source. In conjunction with More Knowledge Others (Vygotsky 1978) they need to scaffold their own learning and to develop a personal knowledge base. At the same time as the dominance of official accreditation wanes, they need to be able to record and present their learning achievement. PLEs are merely tools to allow this to happen.

All this leads to the issue of the role of educational technology researchers and developers. In research terms we need to understand more not just about how people use technology or learning but how they construct a personal knowledge base, how they access different resources for learning, including people and how knowledge is exchanged and developed.

At a development level, there is little point in trying to develop a new PLE to replace the VLE. Instead we need to provide flexible tools, which can enhance existing technologies and learning provision, be it formal courses and curricula or informal learning in the workplace or in the community. It can be argued that while most educational technology development has focused on supporting learners already engaged in educational programmes and institutions, the major potential of technology and particularly of PLEs is for the majority of people not enrolled on formal educational programmes. Not all workplaces or for that matter communities offer a rich environment or learning. Yet there is vast untapped potential in such environments, particularly for the development and sharing of the tacit knowledge and work process knowledge required in many tasks and occupations. PLE tools can help people learning in formal and informal contexts, scaffold their learning and develop a personal learning knowledge base or portfolio.

At both pedagogic and technical levels, context provides a major challenge. While mobile technologies recognize the context of place (through GPS), other and perhaps more important aspects of context are less well supported. This includes time—how is what I learned at one time linked to something I learned later? It includes purpose—why am I trying to learn something? It includes the physical environment around me, including people. And of course it includes the social and semantic links between places, environments, people and objects.

The challenge is to develop flexible applications and tools to enhance peoples' PLEs and which can recognize context, can support people in scaffolding their learning and develop their own Personal Learning Networks and enhance their ability to direct their own learning and the learning of their peers.

Two major European funded projects, ROLE and Learning Layers are attempting to develop such applications. They both have the potential to make major inroads into the challenges outlined in this short chapter.

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Supporting Self-Regulated Learning

Margit Pohl

Current educational theories emphasise the importance of autonomous learning. Self-regulated learning is one example for such a theory. In the context of this theory, metacognition and cognitive strategies play a significant role. One of the goals of the ROLE project was to support metacognition and reflection of learners specifically. Chapter 2 on "Supporting Self-Regulated Learning" describes the basic ideas of this approach and its implementation in the project.

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One relevant issue in this context is the question how much support learners need and how to give appropriate feedback to them. It is well known that autonomous learning often overwhelms learners and increases drop-out. Still, there are individual differences related to the ability to learn autonomously. Students with high metacognitive skills and self-efficacy are better able to plan their learning processes and learn more efficiently. The ability to structure one's own learning and to reflect on the issues raised in the learning material apparently does not come naturally and has to be communicated to the students. In contrast to some constructivist approaches, self-regulated learning takes these issues into consideration. In the context of the ROLE project, specific assistance is given to the learners to increase metacognition and reflection. There is an adaptive mechanism in the support strategies which adjusts the learning material provided to the students to their specific needs. This mechanism also takes care of the fact that some students need more scaffolding than others.

The support process is based on an extremely sophisticated framework consisting of a process model, a competence model and a learner model. This framework enables the system to give highly differentiated feedback to the learners without having to resort to AI methods. The framework enables the researcher to come up with relevant guidelines for the development and adoption of learning resources. In my opinion, the fact that the framework used as a basis for the development process is strongly related to the guidelines is an indication of the value of the didactic approach used in this project. In many e-learning projects the relationship between the underlying theory and the actual design is only very loose which results in a certain arbitrariness of the design.

One of the strengths of the approach adopted in the ROLE project is that the authors also clarify challenges and limitations of their work. They conducted a survey with teachers, and they collected data at summerschools and conference workshops. These data indicate that the approach has advantages and limitations. Teachers described that advantages might be better learning from the students, more autonomy for the students and peer collaboration. They also see problems as, for example, the fact that many students are not equipped for self-regulated learning and reluctant to accept new methods of teaching. There are also barriers because of the way how universities or other educational institutions are organized. These problems have also been described in the literature (Laurillard 1993). The character of assessments at universities, for example, does not encourage self-regulated learning or reflection or collaboration. In addition, metacognitive skills are often not taught in schools or universities. The development of curricula for schools and universities is usually a highly contested area, and many different stakeholders try to influence this process. The introduction of more autonomous and self-regulated learning is, therefore, quite a challenging process. Projects like ROLE can play an important role in this context to present an exemplary realization of self-regulated learning.

I think there are many interesting areas for future work posed by this project. Although some evaluations have already been conducted, a more detailed study of student's interaction with the system would be very interesting. There is a pronounced emphasis on meta-cognitive activities of the students. Students have to tag widgets or formulate their learning goals. I think it is an interesting research question how students adopt these activities. Nowadays, students are not rewarded for this kind of meta-cognitive activities at universities. Therefore, they might see it as an obstacle to get a certificate. I assume that meta-cognitive activities have to be integrated into courses and be rewarded in the same sense as other kinds of learning activities, but these are open questions which have to be investigated.

In general, I think it would be interesting to investigate how students interact with this system. Choosing learning widgets and integrating their contents to form a coherent mental model is certainly a demanding task for the students. It would be very interesting to know how students cope with this task and what can be learned for the design of similar systems. I think that the approach using widgets which can be reused and combined flexibly is very promising, but it is also challenging because it is unusual and forces the students to reflect about their learning processes even if there are only few widgets to choose from. There are two aspects which I think would be relevant in this context. On the one hand, there is the investigation of the interactions and learning processes of the students. On the other hand, it would also be interesting to find out what kind of design can support students best in such systems. The first question is more didactic, whereas the second question also addresses usability issues.

Self-regulated learning is an interesting approach because it combines a more active role of the learner with fairly rigorous learning strategies. Such learning strategies can be an advantage if supported appropriately. The ROLE project is an important step to implement a system to encourage a good balance between freedom and guidance in the learning process.

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Multidimensional Evaluation Framework for PLE: Does It Make Sense and Do We Need It?

Carlo Giovannella

PLEs are a typical expression of our time, a time dominated by the *liquidity*, that from one side is a symptom of a profound crisis of values (Bauman 2000) while on the other may represent a great opportunity (Giovannella 2009), provided you are equipped with the skills needed to manage complexity. PLEs are virtual environments in continuous evolution, potentially no-places (Augé 1992) without memory,

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containing the promise for highly customizable environment and learning processes as amply illustrated by this dedicated publication.

PLEs, thus, are not suitable for most of the today's learning processes and their actors. Certainly not for present teachers, who do not "shine" for the mastery of an adequate digital literacy and who, in the vast majority, still consider virtual environments useful as content repository or message boards. Neither for most of the students that, although belonging to the so called *digital native* (Prensky 2001) and showing a considerable ability/independence in managing interpersonal communication, when are asked to take the responsibility of their own training path step back and, actually, prefer to be hetero-directed and evaluated by teachers. PLEs, thus, are not for today, but represent an interesting laboratory within which one can experiment around the *centrality of the person* and her ability to design her own learning trajectory according to *design based learning* approach, her ability to acquire suitable *design literacy* (Giovannella 2010) and other twenty-first century skills (Giovannella and Baraniello 2013).

A smooth introduction of widgets usage into more "traditional" learning environments would be, thus, largely advisable to foster the transition toward more self-regulated learning paths.

Considering the present conditions the *organizational level* of the evaluation, although should be considered to design a general framework, is too far away with respect to the nowadays urgencies. Since in PLEs the *PERSON* and her learning *EXPERIENCE* is expected to be at the centre of learning process, the evaluation should focus mainly on interplay and co-evolution of the "characteristics" of both people and techno-ecosystem.

As well explained by the authors of Chap. 3 one should go well beyond the standard HCI prescriptions to embrace the whole multidimensional spectrum of the human experience mediated by the machine. Of course one needs to develop a better understanding of the learning experience, develop meaningful models (Giovannella et al. 2011) and try to make these latter as robust as possible. New evaluation methods, thus, should be developed and integrated within (or made more easily accessible from) PLEs, and more in general all kinds of learning environments.

The goal should be the multidimensional evaluation of the *EXPERIENCE* and, of course, of:

- The learner ability to design her learning process (not just to follow the proposed one).
- The acquisition of the relevant competences and literacies and among them the ability to interpret the analytics and self-evaluate her own evolution and needs.

Accordingly the evaluation and redefinition of PLEs usage has to capitalize on the large and well established methodological corpus that have been developed in the past 20–25 years within many disciplinary domains: anthropology, psychology, sociology, computer science, interaction design, design for the experience, design, etc., and that has been well synthesized in Chap. 3 of this book. A corpus that can be even enlarged to consider many other methods (the description of which can be easily found on the web) and that should also be integrated by new approaches and methodologies suitable for the multidimensional monitor of the learning experience (Giovannella et al. 2011, 2013). A task, this latter, that has been accomplished also by some partners of the ROLE project.

The debate on *qualitative* vs. *quantitative* methods and *subjective* vs. *objective* data detection can be considered an ill posed one. No one would renounce to more objective data, collected in an unobtrusive and respectful of privacy manner, no one would renounce to push the border from qualitative toward quantitative data detection, when possible. The debate, thus, has better to concentrate on the quality of data (i.e. "smart data" instead of "big data") and on the ability to interpret them.

As an example, an apparently highly objective detection method like the eye-tracking when not well controlled may produce unreliable results if individual visualization styles are not dutifully taken into account.

As additional example, emotions and sentiment, apart the need of well-grounded and interoperable models, could be both objectively and subjectively detected, but the choice of the approach strongly depends on the time-window of interest and cannot avoid to consider both emitters and detectors, whatever communication modality (voice, text, images, etc.) and medium are involved.

In conclusion, PLEs are *learning labs* challenging all actors of learning processes and researchers in many respects, including a *person/people in place multidimensional monitoring* to detect the acquisition of meta-design literacy, self-direction and self-evaluation skills.

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PLE in Formal Education: Challenges for Openness and Control

Marco Kalz

Abstract This short comment reflects on a critical account of educational technology and makes reference to the chapter by Vieritz et al. about the use of widget bundles for formal learning in higher education.

Introduction

Personal Learning Environments (PLEs) have been intensively discussed since the introduction of the concept without an agreement about their definition and concrete focus. In its early development phase PLE has been introduced as learning technologies under the control of the learner (van Harmelen 2006). Later we have described the PLE as a learning environment in which learners on the one hand actively integrate distributed digital information, resources and contacts, on the other hand document learning progress and learning outcomes based on standards (Schaffert and Kalz 2008). While the original concept of the PLE has been introduced as a counter-concept for teacher/instructor-prepared learning environments like Learning Management Systems (LMS) nowadays this perception of a PLE seems to have moved into a direction in which all technology that enlarges the landscape of standard learning technology can be regarded as a PLE.

The authors of the chapter have presented three case studies of widget bundles that function as an enrichment of the traditional technology-supported learning environments at these three institutions. These implementations provide interesting directions for a transition between learning technologies that are designed according to fixed curricula and prepared content towards more flexible environments. Especially the activity recommender might offer an interesting direction to support self-organized learning. But flexibility alone is not the core of a PLE.

Selwyn calls for a critical account of educational technology that takes into account the societal intertwining of educational technology on the micro-and macro-level and the study of learning technology in dimensions of “power, control, conflict and resistance” (Selwyn 2010). We cannot disconnect this wider discussion and reflection from the implementation level. In this sense, learners need to be able to actively (co-)design their learning environment to make it a personal one. This is the important difference between adaptivity and adaptability of a learning environment (Oppermann and Rasher 1997). While adaptivity can be designed completely according to rules of teachers or the designer of a piece of learning technology, the

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adaptability enables a learner to design the learning environment according to individual needs. In the context of educational institutions and formal learning this leads to a number of challenges.

The authors have argued that pre-designed widget bundles have been used to not confuse users and provide them with too many choices. But this leads to the contradiction that widget bundles are a result of a design process of teachers without giving learners any influence on their technology-enhanced learning environment. We have described this contradiction as a "competence continuum" consisting of a number of core skills to be able to use a PLE effectively for self-directed learning (Wild et al. 2009). The biggest challenge is to come to a setup that also enables learners without a high level of self-directedness and IT skills to slowly get used to a more open and flexible learning environment. Pre-defined spaces that can slowly be extended are one option for this issue, the other option would be to make available a limited number of widgets that users try first and then decide about their use and usefulness.

And this leads to a related challenge: Since PLE are dynamic environments that grow according to the context and needs of the learner their evaluation needs to take into account a temporal perspective consisting of a number of snapshots of the environment and their impact on enabling self-directed learning processes. It is essential for the further development of PLE and their impact in education that the community develops evaluation frameworks that can systematically handle the complexity of evaluating a personal environment that changes its status dynamically over time and can thus fulfill different purposes.

One possible theoretical framework for developing such an evaluation approach is the adaptive structuration theory: „The act of bringing the rules and resources from an advanced information technology or other structural source into action is termed structuration. Structuration is the process by which social structures (whatever their sources) are produced and reproduced in social life" (DeSanctis and Poole 1994). Thus can this theory build a good foundation to analyse the interrelation between social structures and technological structures developed in a PLE and the dimensions pinpointed by Selwyn.

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The Future of PLEs: How Can Higher Education Be Passed?

Martin Ebner

Woolly Thoughts on PLEs for Higher Education

I just read Chap. 5 on “Case study 2: Designing PLE for Higher Education” and would like to sort my thoughts. On the one side the ROLE (Gillet et al. 2010) as well as the Go-Lab project (Gillet et al. 2010) took us a step forward to see how the future of teaching and learning might look like, on the other side we ourselves at Graz University of Technology also gathered experiences how a PLE is used in Higher Education (Ebner et al. 2011; Taraghi et al. 2010). From this personal perspective I would like to enhance the chapter bringing three dimensions in mind. Three factors have to be considered when introducing a PLE to Higher Education institution, at least in middle-Europe:

1. *Technological perspective*: First of all as already written in the chapter a Personal Learning Environment offers more or less both—freedom and restriction. Learners must be able to choose their personal applications, contents, tools for their individual learning process, but should be also able to do this in a secure and private way. In contrast to a teacher-centred Learning Management System we are talking now about a user-centred, flexible, expandable system. From a

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technological point of view it is a kind of a multi-application monitoring environment according to the special needs of a specific learner.

To achieve this goal those platforms are following a widget-based MashUp concept (Taraghi et al. 2011) where different small applications (widgets) can be arranged by users themselves. The web-based software consists mainly of two parts—a framework (the widget container) and the widgets themselves. So the weakness of the concept is maybe also its strength—to run such an environment a high number of widgets for different purposes or learning goals are needed. Graz University of Technology follows the concept of users' programmed widgets, which means that students of informatics are doing this small applications during their projects or exercises (Taraghi and Ebner 2010).

2. *Organizational perspective*: The second major factor of a PLE in Higher Education is the question who is running such an environment and what does that mean to our lecturers? On the one side it seems rather obvious that the system has to be provided university-wide on the other side it must be brought into the mind of each single user—lecturers as well as students. First experiences pointed out that in general such an environment is intuitive and can be well explained with the "App-store metaphor". Due to the fact that nearly everyone owns a smartphone today it is easily imaginable if a Widget is called App and the Widgetstore is compared with the App-store. First gathered statistics pointed out that the PLE in general is used if it is provided university-wide, but still more or less for getting-information issues than teaching and learning purposes (Selver et al. 2013; Taraghi et al. 2013).
3. *Teaching and learning perspective*: Finally it must be taken into account that any system for supporting learning and teaching needs a certain context where it is used and an embedded didactical scenario (Ebner et al. 2011). As described well in the chapter using a PLE for teaching and learning will be a switch from behaviourism to cognitivism. Most of our daily lectures in typical bachelor programmes are based on a face-to-face education where lectures present their contents. It is obvious that this kind of teaching is not appropriate for such an environment where students should aggregate, share, search, recommend etc. It can be summarized that an arbitrarily effort will be necessary on this issue.

Future of Higher Education will need therefore new concepts, lecturers who revise their lectures and learners who will adapt their learning styles. The concept of a Personal Learning Environment and its technical realization is just a first step and the chapter as well as the whole book a first great tribute to it.

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Exploring Open Educational Resources for Informal Learning

Jon Dron

I have been following the ROLE project since its early days and I am delighted to read this report of some of the resulting insights and ideas about how lifelong learning may be supported with its tools. I would like to take this opportunity to interpret some of the findings in this chapter, drawing on both the chapter and my own experiences with the development of widget-based PLE tools.

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One of the most interesting findings related in this chapter is the mixture of feelings expressed by participants as to whether the PLE would be useful. For instance, one of the responses from workshop 2 suggests that the effort needed might not be worth the trouble and, more explicitly, one participant in the Dev8eD workshop comments on the potential difficulties of integrating the ROLE widgets with their existing PLE that included EverNote, Twitter and Google calendar. PLEs are not filling an empty niche: we all assemble our own PLEs, whether we call them that or not. At a broad level, there are PLEs that seek a high level of integration and management of disparate learning tools (that I will refer to as iPLEs), and others that are mostly an aggregation of tools (that I will call aPLEs). The ROLE tools fall mainly into the iPLE category: their purpose is largely to make it easier to aggregate and integrate learning spaces and resources. If this is to work, then it must have extra value not found in other parts of an aPLE. It must be worth the effort to learn to use them. My own aPLE includes a range of personal and shared aggregation tools like browser bookmarks, Pocket, RSS readers and EverNote; productivity tools like calendars, email, Google Search and Apple Widgets; learning objects everywhere, from Wikipedia pages to StackOverflow answers; telephone, Skype, Adobe Connect, social networks, Google Hangouts for dialogue; shelves of physical books as well as virtual collections; a desk, a range of computers and mobile devices; and, most significantly, a set of methods, procedures and pedagogies from which I choose to assist my learning process. Altogether, it is a flexible, highly customized personal learning environment that I use to assemble the things I need for my own learning. There would need to be a good reason to add more tools to this mix. This leads to another quite closely related major issue raised in the chapter: that of usability.

The chapter highlights issues of usability and technical complexity. This is a wicked problem because PLEs tread a tightrope. They must provide a lot of flexibility in order to support an indefinitely large number of potential self-guided learning strategies but they must also make learning easier. For flexibility, they must be fairly soft technologies, in which orchestration of processes and methods is performed by their users. Unfortunately, the softer we make our technologies the harder they are to use, because we must put in the effort to perform the orchestration. If we harden our toolset then some parts of the orchestration must be handled by the tools but, the more orchestration that is built into a technology, the less flexible it becomes. Efficient, demanding less thought, fast: but rigid. Widgets offer a potential solution, by allowing small hard pieces to be assembled into a vast range of learning environments. Using any single widget is mostly pretty simple but knowing which widgets to choose, how they can be configured, how they can be arranged and what they can be used for is much more complex. Thus, though the pieces may be relatively hard, the overall assembly remains soft and therefore difficult to use effectively, requiring an investment in learning and configuring that, unless proven worthwhile, is unlikely to be attempted.

When we talk of self-guided learning we normally mean it only at a coarse granularity: essentially, the absence of an overarching course structure. At a smaller scale, structured learning objects, book chapters, websites, videos and many other teacher-created artefacts are the norm (using "teacher" to mean anyone, including a team of designers or fellow learners, that intentionally or otherwise helps another to learn). So it is with interest that I read this chapter reporting on personal learning environments, but talking about them in the context of intentional teaching, courses, workshops and other planned processes. Self-regulation can occur at many scales. We may choose to control different aspects of the learning process but almost always delegate control to others at many stages, whether to the author of a chapter or learning object, the leader of a workshop, our PLE or the widgets within it.

Some tools described in this chapter such as Etherpad and Flashmeeting hinge on social engagement, which entails a need to be at the very least mindful of the schedules, needs and goals of others. This highlights a tension that exists in nearly all PLE implementations, that they support our social learning activities, but that those social learning activities themselves, with our fellow learners and teachers, provide shape and form to our learning. For instance, I was not surprised to read that relatively little use was made of Etherpad and Chat in the events described: given that participants were collocated it would not normally be very useful to provide alternative real-time collaboration tools, especially as the tasks did not appear to focus on production of a permanent artefact but were simple part of some active experimentation to use the toolset.

At the heart of all my reflections on this chapter is the fact that PLEs are more than just a way to keep things organized in our learning lives. Done well, they are generative toolsets that can act in some ways like a teacher, offering guidance, inspiration, motivational support and structure to the learning experience. But, at the same time, they seek to provide freedom from such a teacher role, to be soft tools to support self-regulated learning. They are thus both teachers and not teachers at the same time. Their innate softness is perhaps the reason that the evaluations performed in this chapter focused on helping people to use the tools in a manner that is anything but self-regulated and explains why it is so hard to pin them down. A PLE is personal: every individual builds processes and methods around them, configures his or her own space but, at the same time, that space is shaped and influenced by the people, resources, learning objects, tools and expertise that are available. This tension lies at the heart of education. When we educate ourselves we choose the parts that we delegate to others more than those who follow a more guided path but, through the shape of our tools, the people around us and simple path dependencies, we have many of our decisions made for us and, at a finer granularity, always delegate at least some of the teaching process to others. Getting the right balance is a tough task to perform well and partly explains why case studies like the one presented here have a vital role to perform in helping us to understand that better.

Workplace Learning at Festo: Content Creation by Workers for Workers

Content Creation by Workers for Workers

Juergen Mangler

Abstract As a follow-up to Chap. 7—an interview with Manuel Schmidt and Michael Werkle was conducted, to delve into how it is possible for Festo to embrace PLE concepts in their organization, about the motivation of workers to create and share content, and about future projects.

Keywords Interview • PLE • Content creation

Introduction

From Chap. 7 we learned that FESTO is to promote informal learning—learning that happens e.g. through interaction of the learners in social media environments. Rather than employing a top down approach, where learners are fed learning material prepared by dedicated content creators, an individualization of learning is aspired for that covers the learning process (i.e. the what, when and the pace), as well as the content creation process. For the content creation process FESTO is focusing on the experts in the fields (i.e. the workers who do something day to day).

In order to find out more about how typically strict learning related policies in a company fit in with the goals of PLEs, the interview was conducted with a focus on the philosophy and benefits related to letting workers create their own learning material during their work-time, and how this fosters learning and collaboration in the workplace.

Both interviewees are members of Festo Lernzentrum, a separate entity inside Festo that maintains the companies' Learning Management System (LMS), oversees content creation, as well as the creation of didactic designs for the training of workers.

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Interview

Interviewer: What is the relationship between traditional e-Learning and PLE's in your Organization, and how was it shaped by the ROLE project?

Manuel Schmidt: The ROLE project served as an incubator for complementing the existing LMS with properties of a Personal Learning Environment (PLE). From the start of the project there was a strong consensus inside Festo, that a pure PLE was *not suitable for the business context*. As motivating workers to maintain and extend their job related skills and knowledge is a primary focus of businesses in general, they also want to control the goals and granularity (i.e. the when and what) of learning. Furthermore businesses want to speed up the process of *getting started*, which they see as conflicting with the nature of PLE's, where the user starts from scratch, e.g. spending lots of time building one's own learning environment through widgets.

Interviewer: Can you describe the typical learning scenarios for Festo workers?

Manuel Schmidt: Festo is, like possibly most businesses, very much focused on individual workers' career paths and individual competence development plans. This formal training of workers is accompanied by e-learning. We focused on allowing workers that have to tutor other workers to create and distribute their own content, e.g. videos. (. . .) 90% of our users are knowledge workers.

While all workers of course are actively encouraged to participate in seminars, which are rigidly structured, we provide complementary e-learning content in our LMS. For this content, workers can decide for themselves if and which parts they want to consume. So even if a learner does not participate in seminars, he/she can select from a wide array of on-line learning material.

Interviewer: Do you have an estimation which percentage of users use your LMS to consume content because of—or complementary to—seminars, and which percentage of users are purely self-motivated learners?

Manuel Schmidt: During 2013, about 50 blended learning seminars with obligatory material provided through the LMS took place, but about 600 courses in total have consumed during the same year.

Michael Werkle: Staff development in Festo relies on two pillars—quantitative and qualitative goal-setting between workers and their supervisors, and self-motivation. The facts are: the 600 courses had a total of about 8,000 users consuming them, and learning videos have been consumed over 13,000 times in the last year.

Interviewer: In Chap. 7, section 'Implementation of the Personal Learning Management System' it is stated that one organizational requirement is to ensure the transparency of the learning process and the yielded achievements. For sure the employer is interested in, and encourages its workers, to improve their skills and competencies. Does Festo have any formal instruments in place for motivating workers, for example awards?

Manuel Schmidt: There are no awards for learners or content creators. We were toying with the thought, but so far nothing has been realized. One important aspect in our organization is the very open culture regarding learning: we allow and encourage the learners to use our on-line resources during normal work-time. This trust vis-a-vis the workers alone translates into motivation.

Michael Werkle: Rewards for content creation can of course also have negative effects. For example the use of Wiki's in companies is often very successful when coupled with reward systems ... but they immediately die as soon as the rewards are taken away. The learning-tube philosophy is successful without any extrinsic rewards.

Manuel Schmidt: We think that systems are successful when the intrinsic reward is obvious for the workers. For example, knowledge workers that have to train other workers are much more flexible when they create videos. The can reuse them in seminars or even refer to them during normal meetings.

Interviewer: Do you track individual learners, their learning progress, ...?

Michael Werkle: This is not possible due to German privacy protection laws, and company level agreements.

Interviewer: Currently the whole approach seems much centred on knowledge workers—workers who do all their work in front of the computer screen—or at least on the knowledge working part of the job. Is there a planned integration of the factory floor learning processes into the system? For example when a worker explains to other workers how certain systems on the factory floor work, or how to make them work better, it cannot be captured by screen-casts.

Michael Werkle: There are several research projects underway for human-machine interaction. We are not sure yet which direction these projects will take.

Manuel Schmidt: For me the question is—how to integrate the LMS into the work environment—or maybe not integrate it at all. For example, content could be attached to machines, and a learner equipped with technology like 'google glass' could access this content directly in front of the machine, in a augmented reality setting. The goal will be 'integration into the normal work environment'.

Interviewer: A very simple step, long before producing content for others is: taking notes for yourself in order to not forget. Learning material is produced for self-consumption. Are there any signs that the learning facilities inside Festo are used like this? To what extent?

Manuel Schmidt: Our content creation process (for learning-tube, Ed.) is two-tiered. First the created content is saved locally, and only in a second step it is published. I know that some colleagues are using the system for personal notes.

My personal estimation is that the ratio between published videos and local videos—consisting of videos that the users are not happy with, and videos that the users created for self-consumption—is about 1:10.

Interviewer: In the conclusion of Chap. 7, it is mentioned that the search mechanisms inside videos are not yet there—specifically full text search is not working because not automatic translation of the spoken word to text is possible. Are there any new developments in this area?

Manuel Schmidt: We tried to set up a project that tackles full-text search for videos with a semi-automatic approach: machine-translation and human lectors.

We furthermore wanted to create tag-clouds for each video. Currently our search only uses tags that have been added by the creator of the video…

Interviewer: … but are the learners allowed to add own subtitles, tags, and notes to learning videos—basically crowd sourcing the creation of data for full-text search? Semantically conceptualized information is after all much more valuable than just the plain full-text, as it allows to find something according to its meaning, instead of the words that are used by the creator.

Manuel Schmidt: This is currently not possible, but will be added in the future. For now we focused version of the platform that supports a recommender system for videos, including comments.

Michael Werkle: Especially interesting—and related to this topic—is internationalization. As we are a multi-national organization, we observe the workers—e.g. colleagues from US and Germany collaborate for bi-lingual videos. It is especially important that the tools not only support such collaboration, but make it easy.

Interviewer: As mentioned in the introduction, media-didactic conception and design is key to the success of learning material. How does Festo tackle the fact that when the content is produced by experts in the field (i.e. with no extra media-didactic education)? Is there a support team that helps the workers who are willing to produce content, without putting an additional post-production burden on him? Or is the content left unaltered and filtered purely by how well is received by other learners?

Michael Werkle: Our observation is: the quality is very high. The content creators are aware that about 15,000 colleagues—including the upper management—can watch created content. Thus they put lots of efforts into the created material. Usually we only have to provide technical support regarding the tool—and more generic tips, like *how to best present my desktop*. The users definitely put lots of effort regarding message and scenario into the content creation process. The users even come up with lots of ideas for the presentation of topics that we would have not thought about.

Interviewer: This raises the question about granularity? How is ensured that one video does not contain too much information (that could be split up into smaller pieces—micro-learning)?

Manuel Schmidt: Videos typically have a duration of 2–10 min, so the content creators intuitively go for the right granularity. As most created content deals with solving a specific problem, a storyline is natural: explain the problem, solve the problem, happy end.

Also one big group of content creators is definitely key (region, E.d.) managers and product managers—they know how to sell products and thus are also qualified to create learning material.

On the other hand, also people with no special skill-set, which even could be described as introverted, created content. In some cases these people work together on videos, i.e. interact regarding the topic of the video in the form of a question-response game. In this case I suspect one person alone would not have created a video.

Interviewer: Evaluation is always a time-consuming process that is easily criticisable because of e.g. sample size, or certain questions used. Additionally, the quality of the properties of a tool is distorted by the very content it provides—in the case of Festo, the videos produced by workers. But they also only produce a snapshot—a glimpse into what a limited group of people thought at a certain time. Is there a permanent evaluation mechanism, that continuously and preferable without placing additional burden on the users (a passive mechanism)? Quantity is important, but what about quality?

Manuel Schmidt: We differentiate between LMS and content. We have a continuous evaluation regarding learning-content, the platform—its functionality—is evaluated with each new release. Currently questionnaires are created in conjunction with courses; the functionality for evaluating single learning objects like videos is included in our next internal release.

Interviewer: Thank you for the interview.

Conclusion

As a conclusion from the interview, it becomes apparent, under the premise that a learning-friendly culture has been established, that businesses have no problems finding motivated workers that create high-quality content, and cooperate with colleagues in content creation. Finding a balance between pure PLE's and traditional LMS seems to be a bit of struggle. Due to already existing formal educational instruments like seminars, and time-restrictions, properties of PLE's seem to be hard to integrate into a company strategy. At Festo the idea of PLE's is manifested as a comprehensive library of learning objects—videos, courses, material—that the learners can select from. It will be very interesting to observe if other companies will move into the direction of allowing learners to create and share own material and courses at an even more fine-grained level.

Finally, the topic of integration the factory floor—non white-collar workers—into these systems will be a challenge, with lots of innovative concepts to be tried out. For example the idea to attach learning material to physical objects including the consumption in an augmented reality setting seems very intriguing.

Lessons Learned from the Development of the ROLE PLE Framework

Sheila MacNeill

Extending the flexibility of learning environments continues to be a challenge for both users and developers. Over the past decade there has been increased demand to ensure that institutionally provided learning spaces are easily adaptable and personalized. Many teachers, learners and VLE administrators have been frustrated by the lack of flexibility and opportunities for customization and personalization in VLEs. Recently, there have been a number of developments that are allowing far more flexible and open approaches to be taken.

In 2010, in response to the increased demands both pedagogically and technically to integrate more social applications into VLEs, Cetis produced the Distributed Learning Environments Briefing Paper. The paper outlined the tensions at that time as:

> the requirement for deeper integration with other (administrative) systems gave rise to the MLE (managed learning environment) concept. Later, the demand for greater personalisation and the availability of new web tools gave birth to the PLE (personal learning environment) debate, in which people radically re-conceptualised the notion of a learning environment. During these phases, however, the VLE still remained a dominant force within institutions. This has resulted in a tension between the role of the VLE as a common tool for the institutional community, the desire to make it permeable to the institutional network and the wider web and to allow greater levels of personalization/customization for individuals and institutions.

The chapter outlined five potential models for the opening up and integration of VLEs with a number of other administrative systems and the wider social web and allowing increasingly flexible access to VLEs from mobile devices

Following the publication of the paper, Jisc funded a small development programme, Distributed Virtual Learning Environments[1] that allowed several relatively small-scale projects to develop solutions based on the models.

Interoperability and flexibility have, and continue to be, central to the work of Cetis, so as this programme developed we actively engaged with a number of other communities working in this space including the Apache Foundation and the ROLE project.

The work of the ROLE project was of particular interest as it provided a useful intersection and more potential technical solution to some of the outstanding challenges from the programme. In particular by providing an underlying open architecture for the creation, deployment and storage of widgets. The areas of

[1] www.jisc.ac.uk/publications/briefingpapers/2012/extending-the-learning-environment.aspx

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development discussed in this chapter were of particular interest in terms of providing potential solutions to HEIs in moving forward the development of more flexible learning spaces.

Interoperability Framework, Architecture

The open framework and architecture developed through ROLE demonstrates the key functionality and communication mechanisms for the deployment and integration of widgets. A significant challenge highlighted by the Jisc DVLE programme was that institutions do not have the capacity to host and manage institutional widget spaces/stores. However the concept of a central, educational specific "app store" did have traction. The concept of an educational specific app store had traction; it just needed a mechanism to make it a reality. Following the Cetis 2012 App Store Conference Session,[2] Jisc funded a pilot project for the Role project to produce a proof of concept store utilizing their developing infrastructure and architecture.

Inter-widget Communication

For widgets to be integrated within a successful PLE, it is necessary for them to be able to integrate with other elements of that environment. Collaboration is an increasing part of many learning experiences. Widgets offer an array of customized collaborative activities. One of their inherent appeals is the fact that learners/ teachers can utilize a variety of widget combinations. In an educational setting such as a course delivered primarily via a VLE, widgets need to be able to access key user information and recognize individuals and groups.

Contextualized Meta-data

As the chapter highlights tracking widget interactions is central to developing responsive learning environments. The growing interest in learning analytics in the sector also points to the desire for more detailed information on user activities. The exploration and instantiation of the CAM schema as described highlight the affordances (and challenges) both for end users and developers that this method of data collection can provide.

[2] http://blogs.cetis.ac.uk/sheilamacneill/2012/02/26/app-stores-galore-at-cetis12/

Spaces

Learning spaces are notoriously difficult to comprehensively define. The boundaries are constantly evolving and being permeated. The concept of space(s) defined by the ROLE framework allows the aggregation of people, resources, applications and spaces. Two approaches—linked data and Open Social are discussed. Both have their strengths and weaknesses, which have been explored and expanded through the work of the project.

Authentication and Authorization

Authentication and authorization of users and data is a vital element of widget deployment in a PLE context. The chapter highlights the two levels of data communication methods needed for authentication and authorization—service-to-service and widget-to-widget. More work has been done on the later, in particular with recognized authorization services such as OAuth, which provides a level of user control over sharing of data in specific spaces.

The chapter provides a comprehensive overview of the potential of the ROLE framework in the development of increasingly adaptable and sophisticated personal learning environments. From a personal point of view, it was very rewarding to play a small part in joining up developments within the UK HE sector with the wider European context provided through the ROLE project.

Reference

MacNeill, S, Kraan W. Distributed learning environments, Cetis. http://publications.cetis.ac.uk/2010/46. Accessed Feb 2014.

ROLE Consortium: Research Institutions

	Fraunhofer-Institute for Applied Information Technology—FIT, Germany http://www.fit.fraunhofer.de
	RWTH Aachen University, Germany http://www.rwth-aachen.de
	Technical University of Graz—TUG, Austria http://www.tugraz.at
	Katholieke Universiteit Leuven, Belgium http://www.kuleuven.be
	University of Koblenz, Germany http://www.uni-koblenz-landau.de
	Uppsala University, Sweden http://www.uu.se/

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	Ecole Polytechnique Fédérale de Lausanne—EPFL, Switzerland http://www.epfl.ch
	University of Leicester, UK http://www.cs.le.ac.uk
	Open University UK—UKOU, UK http://kmi.open.ac.uk
	Vienna University of Economics and Business, Austria http://www.wu-wien.ac.at
	Festo Lernzentrum Saar GmbH, Germany http://www.festo-lernzentrum.de/
	IMC Information Multimedia Communication AG, IMC—Germany http://www.im-c.de

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	The British Institute for Learning and Development—BILD, UK http://www.thebild.org
	Shanghai Jiao Tong University—SJTU, China http://www.sjtu.edu.cn/
	Centre for Social Innovation—ZSI, Austria http://www.zsi.at
	U&I Learning NV—UIL, Belgium http://www.uni-learning.com

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Supplementary Material

Links to relevant websites and software

ROLE Project Website:
http://www.role-project.eu
ROLE Widget Store:
http://www.role-widgetstore.eu
ROLE Software on GitHub:
http://github.com/ROLE/ROLE
ROLE Software Documentation:
http://role-project.sourceforge.net/wiki/index.php/Main_Page
ROLE Network on LinkedIn (currently 720 members):
http://www.linkedin.com/groupInvitation?gid=1590487
ROLE Videos:
http://www.role-project.eu/Videos
ROLE Online Courses:
http://tinyurl.com/role-course
http://tinyurl.com/role-srl-course
ROLE eBook:
http://bit.ly/self-regulated-learning

S. Kroop et al. (eds.), *Responsive Open Learning Environments*,
DOI 10.1007/978-3-319-02399-1

Index

S. Kroop et al. (eds.), *Responsive Open Learning Environments*,
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