First Steps towards an Integrated Personal Learning Environment at the University Level

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Abstract. Personalization is seen as the key approach to handle the plethora of information in today's knowledge-based society. It is expected that personalized teaching and learning will efficiently address learner needs. The education of the future will change as a result of the influence of Web 2.0 content typified by a steadily increasing supply of data. This means that the students of tomorrow will regularly have to deal with sharing and merging content from different sources. Therefore, mashup technology will become a very important lens by which to focus on individual learning needs and enable personalized access to particular information. The following paper describes the challenges of Personal Learning Environments at higher education institutions. In the first section, the concept of Personal Learning Environments is presented, while the second section discusses the new challenges that arise for learning with the help of Personal Learning Environments. The third section describes the technical background of Personal Learning Environments and the widget standard in general. In section four, a first prototype of a personal learning environment will be presented, which is integrated into the learning culture at the Technical University of Graz. A detailed description of the available widgets for the prototype, along with a first expert evaluation, is provided. Finally, the conclusion of the article consolidates the main points of the paper and present plans for future research together with the prospective developments.

Keywords: adult learning; architectures for educational technology systems; distributed learning environments.

1 Introduction

Since Tim O'Reilly (O'Reilly, 2006) referred to the booming possibilities of interaction and communication within the Internet as 'Web 2.0', a new era of the

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World Wide Web began. Interaction among people, as well as content-sharing, has increased dramatically. Sharing and collaborating by way of social software has become a common activity. By the same token, communication and debate through social networks is nowadays almost as normal as e-mail. It is a fact that our social life and our working environment, along with our learning and teaching behavior, are increasingly influenced by Web 2.0 technologies, due largely to its ubiquitous availability and pervasive use (Holzinger et al., 2006; Klamma et al., 2007). Downes labeled the use of Web 2.0 technologies for teaching and learning purposes as E-learning 2.0 (Downes, 2005). Numerous research papers have established several different possibilities of didactical settings for this new approach (Ebner, 2007). Apart from web-based software – wikis (Augar et al., 2004), weblogs (Farmer & Bartlett-Bragg, 2005), or podcasts (Towned, 2005) – the integration of Web 2.0 elements into current learning and teaching scenarios generates a vast potential for creating new learning environments. Nowadays, not only social software like Facebook (social networking) or Twitter (micro-blogging) is important for learning (Ebner & Maurer, 2008), but also platforms for sharing different kinds of media, like YouTube (video), Slideshare, Scribd (presentations and documents) or Del.icio.us (bookmarks) make up for an integral part of the innovative teaching methods that strengthen informal learning processes (Mason & Rennie, 2007).

Considering the enormous number of rapidly growing applications intended for the purposes mentioned above. Efficient management of these tools can become extremely challenging. Therefore, it is understandable that teachers and learners may be overwhelmed by the extensive possibilities that Web 2.0 tools offer. Surprisingly enough, various studies on Web 2.0 technologies have shown that first-year university students are largely unaware of the existence of numerous Web 2.0 tools (Nagler & Ebner, 2009).

Personal Learning Environments (PLEs), also referred to as mashups, can be of great assistance in managing multiple tools, along with handling information and the cognitive overload that comes with it (Kulathuramaiyer & Maurer, 2007). “The possibility to connect different resources in one environment should help to maintain the overview of all activities. Mashups merge content, services and applications from multiple websites in an integrated, coherent way” (Tuchinda et al., 2008). Therefore, PLEs offer a new form of personalized learning (Wild, Mödritscher & Sigurdason, 2008).

This paper describes the challenges that Personal Learning Environments present for higher education institutions. In section two, new challenges for learning and the information overflow will be discussed, whereas section three will describe the technical background of Personal Learning Environments and the widget standard in general. In section four, a first prototype of a personal learning environment for higher education systems will be presented, which has been integrated into the learning culture at the Technical University of Graz. This section will also give a detailed description of the available widgets for the prototype and provide a first expert evaluation. Finally, the conclusion of the article will consolidate the main points of the paper and present the plans for future research, including prospective developments.

2 The Development and Concept of 'Personal Learning Environments'

The challenge and possibility to connect and mash-up different web-based applications was the cradle for developing a new concept in the field of technology-enhanced learning. In this way, the idea of a 'Personal Learning Environment', in short PLE, was born (Olivier & Liber, 2001). Existing technological concepts of learning and teaching by using the Web, like the Learning Management System (LMS), have mainly been developed to support formal teaching needs, such as student management and course organization. In contrast, the PLE concept focuses on the individual learner and his/her personal learning interests. This means that within a PLE, learners arrange and use web-based (learning) content and web-based (learning) tools to support their personal knowledge management and learning.

Olivier and Liber (2001) were among the first scholars to examine the idea of a personal learning environment. A few years later, Wilson (2005) sketched an image of a future 'virtual learning environment, where he integrated external services and enhanced them through applications. By 2006, PLEs had gained in popularity. This fact was proven by the results of an analysis of the search term 'personal learning environment', carried out by Google Insights (Google Insights, 2009) and was supported in several publications. (Attwell 2007; Liber & Johnson, 2008).

To sum up, the current definitions of PLEs are defined as learning applications that enable learners to integrate and organize dispersed online information, resources and contacts, and furthermore allow for content and other elements developed in a PLE to be applied in other online environments (Schaffert & Kalz 2009).

PLEs are not the first attempt to personalize learning content; on the contrary, there is a long tradition of Instructional Design and Adaptive Learning. Instructional Design follows the idea of fostering the learning outcome on the basis of bite-sized, sequenced instruction bits. Particularly in the field of artificial intelligence, the possibility of an automatic 'personalization' of the content is considered as an automatic adaptation of the learning content by a system, pre-defined by an expert model. For several reasons, the aforementioned ideas seem to have become outdated or not further applicable (Schaffert et al., 2008): "(i) learning is mainly dynamic, permanently under development and only shallowly categorized; (ii) referring to current learning theories, the learners are to be seen as active, self-organized creators of their learning environment, and (iii) social involvement and interaction is crucial for learning." Additional arguments for applying new forms of personalized learning focus on new ideas of learning (Wild, Mödritscher & Sigurdason, 2008, p. 2): "learning to learn is more important than (re-)constructing field-specific knowledge, therefore the establishment of a (networked) learning environment can already be seen as a learning outcome. From a pragmatic point of view, a system that was built on emergence should be more powerful than 'programming' by rules."

New possibilities, perspectives, insights and challenges, have catapulted interest in the PLE concept. But while it seems to be an interesting but not a very well developed or elaborated concept it seems that there is limited practical implementation as an innovative approach within technology-enhanced learning and especially within the field of higher education.

2.1 How the PLE Concept Challenges Higher Education

First of all, PLE is a technological concept because it describes the functionalities that a system should have to actively support personalized learning on the Web. It challenges the educational organization of traditional LMSs and the formal learning style.

Teachers and educational institutions are interested in supporting and fostering learning processes and activities of their learners. It can be observed that the selection of suitable tools has a pronounced impact on the students if the institutions offer them engagement in virtual learning phases. Nevertheless, this decision may inhibit learning and teaching processes, for example as a result of the limited possibilities of interaction among the students or a lack of opportunities for learners to create their own content.

Terry Anderson (2006) identified the disadvantages and advantages of PLEs over LMSs. He gave six advantages in comparison with LMSs, namely: identity (learners have various identities outside the formal school environment), ease of use (customization by the users themselves), control and responsibility of ownership (content belongs to the user), copyright and reuse (the owner and not the institution has to make these decisions), social presence (support of communication and 'online culture') and capacity of speed and innovation (new applications evolve rapidly and new features invade the PLE conglomerate in the learning setting).

The following table provides an overview of seven crucial aspects of the shift from the LMS to a PLE that are identified as important changes and challenges (Schaffert & Hilzensauer, 2008).

Schaffert & Hilzensauer (2008) observe that the shift from a LMS to a PLE challenges several norms: The role of learner has to shift from consumer to 'prosumer', which means that self- organization is possible and necessary; learner need certain competencies to organize their learning, to search, find and use appropriate sources; and also, knowledge of personal data is required. What is more, a shift in educational and learning culture is not only a precondition but also a consequence of actively supporting and implementing PLEs.

According to what has been established so far, currently there no real shift from LMS to PLE is taking place. Instead, it is more likely that the concept of PLE will gradually gain ground. In the sphere of higher education transformation is difficult, because managerial requirements will be higher in formally organized learning environments than in higher education. Nevertheless, available on the Web of a plethora of tools and content will encourage educational institutions to support the concept of PLEs.

2.2 Challenges of PLEs for Learners

A common problem for mashups and PLEs is the amount of data gathered within a short time span. Depending on the type of widget that is integrated into a PLE and the number of people adding content to the widget, an enormous amount of information can be collected, which may have an overwhelming effect on the user. This particularly applies to a widget acting as a window for online communities that frequently contribute content to the widget. Particularly text-based widgets that are based on blog posts, social bookmarks or micro-blogging statements, are frequently

Table 1. An overview of seven crucial aspects of the shift from a LMS to a PLE (Schaffert & Hilzensauer, 2008)

		LMS	**PLE**	**challenges & shifts**
1	Role of learner	learner as consumer of predefined learning materials, which depend on the 'creativity' of the teacher	active, self-directed, creator of content	shift from consumer to 'prosumer' self-organization is possible AND necessary
2	Personalization	... is an arrangement of learning assignments and materials according to a (proposed or predefined) learner model, based on an underlying expert system	... means to get information about learning opportunities and content from community members and learning services corresponding to learner interests (via tags/RSS)	competence for the usage of several tools and self-organization are necessary
3	Content	developed by domain experts, special authors, tutors and/or teachers	the infinite 'bazaar' of learning content on the Web, exploring learning opportunities and services	competences necessary to search, find and use appropriate sources (e.g. Weblogs)
4	Social involvement	limited use of group work, focus on the closed learner group (e.g. in the LMS), collaboration and exchange not in the centre	community and social involvement (even in multiple communities) is the key for the learning process and the recommendations for learning opportunities	community and collaboration as central learning opportunities
5	Ownership	content is generally owned by the educational institutions or the students; for technological reasons, this ownership cannot always be claimed	content is organized in multiple, web-based tools, ownership is held by the learners themselves and/or (commercial) service providers	knowledge of personal data is needed
6	Educational & organizational culture	imitation of classroom learning course-orientated, teacher-orientated features	self-organized learner in the centre	change of learning culture and perspective – move towards self organization and self determination
7	Technological aspects	classic learning content needs interoperability between LMS and data repositories	Social software tools and aggregation of multiple sources	required interoperability between LMS and social software

updated. Therefore, a significant time has to be invested to follow them. Yet not every learner or student can afford to invest the required amount of time on a daily basis; that is why a pre-selection of information might be an efficient solution to direct learners to find the required information more quickly. In the long run, the overwhelming effect also applies to media-driven widgets (videos, pictures, presentations) that address public web-services such as YouTube, flickr and Slideshare. Moreover, the size of the community is a critical factor for the overwhelming effect. On the one hand, if the community is small, the learners are not able to gain a broad enough overview of the information needed. On the other hand, when the community is too large, the learners are not able to cope with the amount of information since it is updated too frequently. In the latter case, the learners need to structure and filter the information flow, otherwise it becomes difficult to gain an overview of the available content and identify the most suitable items for certain tasks (Hummel et al., 2007).

The recommender system technology, known from e-commerce systems, could aid learners to establish their priorities and filter through the information overflow. The main purpose of e-commerce recommender systems is to pre-select information that users might be interested in, in order to offer suitable products that fit their personal taste. The most prominent example is the Amazon.com recommender (Linden, Smith, & York, 2003), which suggests related products based on the product search history of a user. Drachsler et al. 2009 applied the recommender system approach from e-commerce and implemented it in a mashup PLE for non-formal learning to suggest most suitable Web 2.0 items to learners. In the so-called ReMashed system[1], a recommender system was integrated, which suggests the most suitable content, showing up in various Web 2.0 services within a PLE to a learner by using his/her tags and ratings (Drachsler et al. 2010).

3 Technological Background of the PLE

The goal of a PLE cannot be reduced to a platform for accumulating distributed learning applications used at university or on the Internet. One of the goals is certainly that the students are able to adapt the learning environment to their preferences, so that they can make their own decisions on which applications they want to use and integrate into their environment. By the same token, each application or service that is integrated into a PLE should be flexibly configurable to meet the individual needs of the student. From the technical point of view, a PLE is a client-side environment (Rich Internet Application) that comprises a mashup of different small independent web applications and services selected by the user. These distributed applications are configurable and can communicate with other web applications within the PLE environment. What is more, Hoyer (Hoyer, 2008) noted some existing mashup tools with different emphases, such as Yahoo Pipes and Microsoft Popfly. Aumueller and Thor (Aumueller & Thor, 2008) describe three main components of a mashup application: data extraction, data flow and presentation. They categorize mashup tools according to one or several of these components.

[1] http://remashed.ou.nl (last visited 10.03.2011).

At the Technical University of Graz a PLE is being developed that is based on a mashup of widgets according to W3C widget specifications. To end-user mashups, it can be classified as described in Gamble and Gamble (Gamble & Gamble, 2008). Applying widgets in a PLE can have several advantages. Widgets represent independent web applications and hence they can be implemented independently from a PLE. The W3C widget specifications, which are explained briefly in the next section, introduce a unique standard for widgets. If this standard is applied, it could result in many open source widgets that can be employed across PLEs and other learning systems, supporting the W3C widget specifications. Another issue is the distributed knowledge transfer from different servers, along with diffusion. Remote servers provide widgets with the corresponding services through their API (Application Programming Interface). Widgets cannot send 'cross-site' requests to remote servers because of browser security restrictions. Yet, there are some techniques that enable bypass of these restrictions, such as JSONP[2] or HTTP Access Controls[3]. In our case, a proxy script is used on the PLE server to enable cross-site communication between widgets and remote services.

In the following section, widgets in general as well as the widget specifications of World Wide Web consortium (W3C) are described.

3.1 Widgets

Widgets are small embedded front end applications that can be included in any (X)HTML page. They include the client-side programming logic and the presentation layer. They can be developed in any common client-side language, such as (X)HTML + JavaScript, and Java-applets. The server-side logic of the applications is no longer responsible for the presentation layer. Its only task is to provide the clients (widgets) with the data and resources they need for using an API in a Service Oriented Architecture (SOA). Widgets are very often used on personalized web sites or personal desktops where users are supported to aggregate and create their own configuration of widgets. iGoogle[4], Netvibes[5], Protopage[6] and Pageflakes[7] are some examples of such personalized desktops. The most famous projects that provide developers with tools to develop widgets are the Konfabulator from yahoo widgets, Dashboard from apple project, Desktop widgets from Opera, and Google gadgets.

3.2 The W3C Widget Family of Specifications

Different types of widgets require different widget engines. Widgets of one widget engine, like iGoogle cannot be applied in others, like Netvibes. The W3C widget family of specifications contains a series of specifications to gain a standard for

[2] http://en.wikipedia.org/wiki/JSON#JSONP (last visited: 10.03.2011).
[3] http://www.w3.org/TR/cors/ (last visited: 10.03.2011).
[4] http://www.google.com/ig (last visited: 10.03.2011).
[5] http://www.netvibes.com/ (last visited: 10.03.2011).
[6] http://www.protopage.com/ (last visited: 10.03.2011).
[7] http://www.pageflakes.com/ (last visited 10.03.2011).

widgets and remove the lack of interoperability among widget engines. 'Widget Packaging and Configuration'[8] 'The Widget Interface'[9] and 'Widgets 1.0: Digital Signatures'[10] are three W3C candidate recommendations that are described here briefly for the sake of completeness:

- 'Widget Packaging and Configuration' needs the zip packaging format to include all the widget files, folders and the XML configuration file, along with some mandatory and non-mandatory elements. It also specifies the behavior and means of error handling for widget user agents.
- 'The Widget Interface' defines a set of APIs and events and deals with the functionality within the widget scope. It defines the corresponding methods to access meta-data that are declared in the widget configuration file and methods to receive events related to changes in the state of the widget.
- 'Widgets 1.0: Digital Signatures' deals with the digital signing of widgets. It defines a profile of XML signature syntax and processing specification to allow a widget to be digitally signed by widget authors or distributors.

4 Proof of Concept - A PLE for Higher-Education Institutions

At the TU Graz we implemented a first prototype of PLE that offers centralized access to various University services, like administration systems, LMS or blogospheres in one overview. The users can personalize the PLE to their individual information and learning needs. In addition, public services of the Internet are also offered in the PLE. For each of these services, a widget has been developed that can be integrated into the PLE. Fig. 1 shows a conceptual view of the PLE of the TU Graz that integrates University portals and other Internet services.

The widget engine used in the TU Graz PLE is an extension of the widget engine that was first implemented within the scope of the IST Palette project[11] for the Palette web portal. The widget configuration file, which is specified in W3C Widget Packaging and Configuration, has been extended to add some default user preference values in order to facilitate widget customization. What is more, the W3C Widget Interface has been extended to enable widget intercommunication within the PLE environment. Communication can run in the background automatically or can be directed manually by the user, for instance as a drag and drop event for data flow between two widgets. The TU Graz PLE represents a web portal that students can fully adjust to their personal needs by adding and removing widgets as well as modifying widget preferences. The PLE widget engine distinguishes between local widgets, which are installed on the PLE server, and remote widgets, which can be installed on any remote server. By using this extension, widgets do not need to be installed on the PLE server.

[8] http://www.w3.org/TR/widgets/ (last visited: 10.03.2011).
[9] http://www.w3.org/TR/widgets-apis/ (last visited: 10.03.2011).
[10] http://www.w3.org/TR/widgets-digsig/ (last visited: 10.03.2011).
[11] http://palette.ercim.org/ (last visited: 10.03.2011).

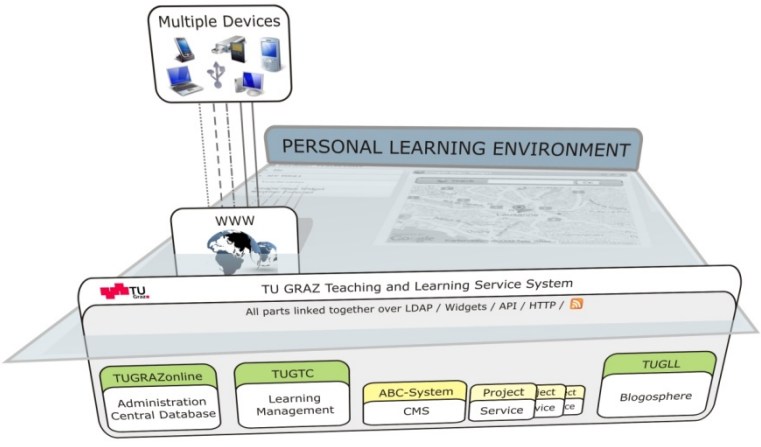

Fig. 1. PLE concept: aggregation of different services from distributed university portals and other applications on the Internet

The following sections examine the structure of the user interface and demonstrate some widget prototypes that have already been implemented in the TU Graz PLE.

4.1. User Interface (UI)

The PLE Graphical User Interface (GUI) is a combination of a traditional UI with a sidebar element and banner for orientation and navigation. In addition, it offers a widget-based UI with the so-called 'widget zones', which require an adjustment by the user (Fig. 2).

Widgets are categorized according to pre-defined topics. Each widget topic (category) has its own widget zone. The sidebar elements contain the main widget topics and help the user to switch between widget zones. The topics are easily extendable if the number of widgets is increasing. Furthermore, the sidebar also updates the user on the status of the widgets by means of color and numerical indicators. The sidebar can be switched off in favor of the unfamiliar widget-based UI and replaced by another navigation element, which resembles the Mac Dock menu on the bottom part of widget zones. The widget topics include different areas related to formal and informal learning: 'Communication Center' for emails, chats and news groups; 'TeachCenter' for all services related to the TU Graz LMS system, such as course materials, podcasts etc.; 'LearnLand' for services related to the TU Graz blogosphere system social bookmarking, file sharing, etc.; and 'Help and Support' for the help desk as well as FAQ. Widget zones contain widgets and are structured in columns. The user can switch between widget zones, add (open), close, customize, position and arrange the widgets in different columns according to her/his personal learning preferences. Moreover, the user is able to create a mashup of the most frequently used interesting widgets from different widget zones in a special interface called 'Personal Desktop'. The personal desktop is always available to the user and can be activated at any time. When the user activates the personal desktop it overlays

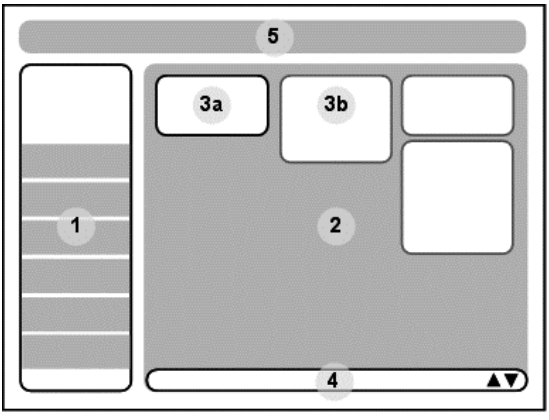

Fig. 2. PLE User Interface. 1) Sidebar elements contain widget topics; 2) Widget zone contains the widgets that belong to a widget topic; 3a and 3b) Widgets within the corresponding widget zone; 4) Hidden 'Personal Desktop' containing a mashup of widgets from different widget zones selected by the user. 5) Banner displays information in context of the active widget zone from the network.

the whole screen from the bottom of the page upwards (Fig. 2 part 4). Users can add or remove widgets from all widget zones to a personal desktop and arrange them in columns according to personal needs. On the top of the page there is a graphic element called 'banner' (Fig. 2 part 5), which contributes to brand a site and help the user to locate contents and orientate himself. But its main purpose is to display information from the network in a user-profile-sensitive way. It also keeps track of the currently active widget zone. The widgets consist of a front side and a rear side, where the rear side contains the widget preferences that can be modified by the user.

4.2 Widget Prototypes

Some first widget prototypes have been developed by computer science Master students according to their interests. The widgets vary from different distributed applications of the Internet to various services within the University to enhance formal learning and foster informal learning scenarios.

Some university widgets

- The "blog" widget allows users to read weblog postings from the blogosphere of the university (Fig. 3). Users can customize the widget to their favorite blogs, a specific blog community, or to all items from the blogosphere.
- LMS widget (Learning Management Widget), for instance, presents a view on the existing LMS system of the TU Graz (Fig. 4). The widget presents a list of courses a student has access to. Selecting a course displays the e-learning materials related to that course. In addition, some supplementary widgets, such as a timetables and a location widget, can be auto-synchronized in the background to provide the user with information regarding the place and the time schedule of

the course. An alert widget informs the student as soon as a course is cancelled or new notifications are coming in.

- LO widgets (Learning Object Widgets) linked to several courses are suitable to be used in the PLE. As an example, a widget was developed for the course *Design and Analysis of Algorithms* that demonstrates different algorithms (Fig. 5). The "Truth table" widget is used for Informatics students in first semester to try out and learn logical mathematical operations. There are some more LO widgets currently under development, such as a 2D and 3D function plotter for mathematic courses.

Some useful widgets from the Internet

- The Twitter widget enables users to follows twitter streams. The users can customize the widget to be able to follow the tweets of every other user. What is more, a tag-based search module in the public stream of twitter is provided.
- The "RSS Feed Reader" widget allows users to aggregate and follow published Internet content through RSS feeds in the PLE.
- "Google Maps", "Google Calendar" and "YouTube" widgets represent the corresponding services from Internet.
- "Translation" and "TODO" widgets are some other examples of running widgets.

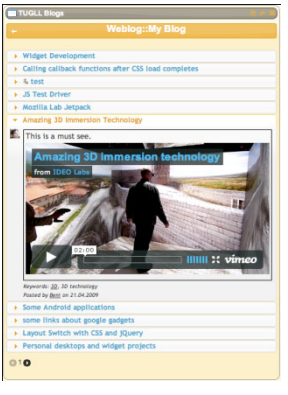

Fig. 3. Blog widget displaying blogs from the blogosphere system

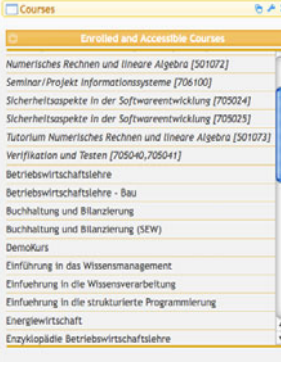

Fig. 4. LMS course widget displays the list of accessible or enrolled courses to a user

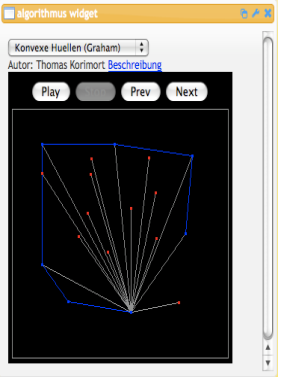

Fig. 5. LO widget displaying the functioning of the Graham Scan algorithm

5 Conclusions and Future Work

This paper described the challenges that the introduction of Personal Learning Environments pose for higher education institutes. In section two, new challenges for learning and the information overflow were discussed. In the following section, the technical background of Personal Learning Environments and the widget standard in general was presented. A proof of concept was presented in section four, namely a personal learning environment that has been integrated into the learning culture at the

Technical University of Graz. A detailed description of some of the available widgets for the prototype was also provided. In the final section that follows, we conclude with an outlook on future research and developments plans.

As already mentioned, a common problem for mashups and PLEs is the amount of data that is quickly gathered in a short time span. To overcome the overwhelming effect and help the users to structure and filter the information flow within the PLE, we plan to investigate four possibilities to apply the recommender system technology within the PLE of the Graz University of Technology.

1. A study path recommender system: The University of Stanford in the US developed a study path recommender system that suggests alternative courses to students to improve their study time. The CourseRank system (Bercovitz et al., 2009) is a free study planner that offers the students access to information about their courses, lectures and alternative choices. It supports the students in selecting the most suitable course by demonstrating the decision of the students on certain courses through the recommender system. CourseRank uses feedback information of the students (indirect ratings) about the courses offered and makes this accessible to all the students at the campus. In that way, CourseRank makes the tacit knowledge about courses only available by word-of-mouth, while the brief course descriptions are made explicit and widely available to all students. The students can anonymously rate courses they have taken, add comments and rate the accuracy of other comments. They receive personalized recommendations and are able to organize their courses in their study schedule. CourseRank extends the knowledge base of the students by identifying the most efficient and effective study path through a selection of courses at the university. The implemented recommender system technology sets CourseRank apart from traditional study planner tools. A similar approach could be considered for the TU Graz PLE. The recommender system could also be designed as a widget and integrated into the PLE.
2. A widget recommender system: Nowadays, an increasing number of recommender systems are no longer designed to recommend content or persons, but rather recommend certain web services, applications or widgets to individual users (Kokash, Birukou, & D'Andrea, 2007). Depending on the amount of widgets available for a university PLE, a recommender system for widgets should be a reasonable choice; especially in case the university follows an open policy that allows the students to integrate and develop their own widgets for the PLE. Such a widget recommender could be integrated into the dashboard interface of the PLE suggesting certain widgets to particular students. It could also recommend different sets of widgets to a student on the basis of study domain or course selection. For instance, a computer scientist student that has subscribed to a course in computer algorithms could take advantage of the algorithm visualization widget (Fig. 4a). Thus, with subscription to the course, the recommender will suggest this particular widget to the student. The recommender would be based on a top-down knowledge-driven recommender technology, as in e-commerce systems for complex products like insurances (Felfernig, 2005). But it can also be combined with bottom-up technology, like collaborative filtering, and allow the students to assess if a widget is valuable or not.

3. A peer student recommender system: Another scenario to apply a recommender system at university level is to increase the connections among the students on the campus. This could be done either for short problem-solving issues, as Van Rosmalen et al. (2007) demonstrated with a 'question-answering' tool that recommends the user a list of other students to be considered to solve a certain question. But that could also be applied to complex problems or themes to which the students are committed. Similar to the CourseRank system, knowledge about specialist areas according to distinct topics can be made explicit and returned to the students. That way, special interest groups throughout different semester levels could be created and bring together students who are interested in the same topics. The system could recommend peer learners to meet and prospective candidates to create learning groups or communities of practice. Nevertheless, this approach requires student agreement to allow other students to contact them over their e-mail or phone number. Shared interests of students could be established by comparing their tag cloud, search terms and documents used in the past.
4. A hybrid recommender system: Finally, there is a real possibility to create a hybrid recommender widget that combines aspects of other scenarios in one recommender widget. Such a hybrid approach could be sensitive to various activities within the PLE. It could for instance be sensitive to search terms entered in the search widget of the PLE environment. Or it could request a combination of information related to the search term and present them in one overview. Apart from that, it could also request a definition for the search term from the Web (Wikipedia), recommend documents (from the Web or the university repository), and suggest peer students for learning groups.

In addition to the recommender research perspectives, we will extend the PLE to mobile clients. From the technical point of view, the PLE and the widgets are implemented on the basis of MVC design architecture (Model View Controller). This pattern makes it possible to extend the whole logic, user interface or client-side data layer without interfering with other modules. One of our next steps will be to extend the view modules so that the PLE and the widgets can also be applied in mobile clients.

- What is more, the extension of the model modules to local storage or database storage that are specified in HTML 5 makes it possible to build offline widgets. Following these extensions, the PLE can be used offline and in mobile clients.
- The overwhelming flood of information and distributed services on the WWW and within universities, means there is a need to provide PLEs for higher education. Combining mashups with appropriate recommender systems would support students in finding the required services easily and filter the flow of information in the PLE efficiently.

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