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Tackling Engineering Education Research Challenges: Web 2.0 Social Software for Personal Learning

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Abstract

This paper focuses on Engineering Education Research on Technology Enhanced Learning carried out at the Swiss Federal Institute of Technology in Lausanne (EPFL), and on its current focus on personal and collaborative learning. After some thoughts on the distinctive nature of Engineering Education Research, the interplay between engineering education practice and professional engineering practice is analyzed. In particular, it is demonstrated how the actual engineering practice of the faculty members influenced the acceptance and the success of new learning approaches and solutions. Finally, the impact on the current Web 2.0 paradigm is discussed and illustrated with the example of project-based collaborative learning activities supported by innovative social software that can be considered as a Personal Learning Environment. A vision of how to shape and exploit personal learning environments to tackle engineering education research challenges is also presented; this deals especially with the importance of user-driven recommendation mechanisms relying of proper trust models.

1. Introduction

This paper focuses on Engineering Education Research (EER) on Technology Enhanced Learning (TEL) carried out at the Swiss Federal Institute of Technology in Lausanne (EPFL) in the framework of European integrated research projects. TEL is the European acronym used for describing approaches and solutions related to e-Learning. The European Commission has invented this acronym to try to avoid the negative techno-centric connotation of e-Learning and to enforce the fact that technology is an addition for enhancing learning, rather than a new learning paradigm. The research initiatives launched in this framework are detailed, with special focus on the way to capitalize on the personal learning paradigm with appropriate Web 2.0 learning services. Personal learning stands for self-directed learning where communities play an important role. It should not be mixed up with individual learning.

EER is a new discipline that the engineering education community is trying to establish [1]. A rich set of literature focuses on proposing relevant definitions and agendas taking into account the Grand Challenges of engineering [2]. As a contribution to its definition, one could say that the distinctive nature of EER is that it is conducted and results are published by engineering faculty members, who are preferably still involved in engineering research but with a commitment for or a specialization in education. It is also an experimental discipline driven by practical needs, such as supporting the development of soft skills, and validated in the actual practice of engineering education. Such a definition helps to differentiate EER from education research in general. In the latter, innovation is more driven by theoretical hypotheses and validated by controlled experiments. EER is a highly interdisciplinary domain that is closer, in that sense, to knowledge management. EER is also oriented towards the design of innovative or effective approaches and solutions, while education research put more emphasis on the diagnosis, analysis and understanding of existing settings. The strong relationship existing between TEL and Knowledge Management (KM) has been recognized recently and is becoming a relevant framework to close the present gap between engineering education practice and professional engineering practice as discussed in Section 2.

The interdisciplinary nature of TEL in EER is represented in Figure 1. Computer and communication sciences deal with the hardware and software infrastructures exploited in TEL, as well as their integration schemes and protocols. Educational, social and cognitive sciences deal with learners, as well as learning approaches and settings. They also provide methodologies for evaluations that are necessary to assess TEL. Information systems, knowledge management and engineering deal with the design and the deployment of solutions and processes for people, organizations and enterprises. Learning management systems and digital libraries are such solutions exploited in TEL. Engineering appears in this framework not only as a field of deployment for TEL, but also as a discipline enabling smart devices, such as online experiments, sensor networks and even classroom furniture, to be integrated as learning resources in an Internet of Things perspective [3]. Interconnected people are referred by analogy as the Web of People as coined by Tim Berners-Lee, the inventor of the World Wide Web.

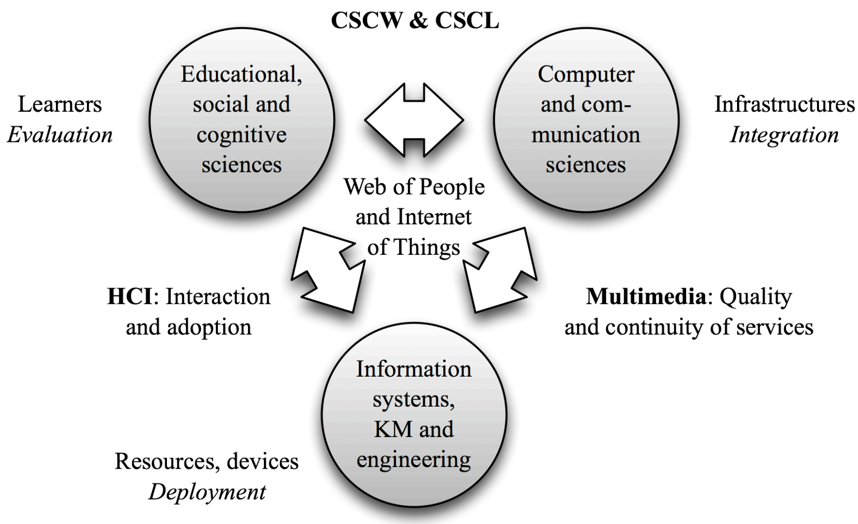

Fig. 1. The interdisciplinary nature of TEL in EER with key challenges located at the interfaces between traditional academic disciplines.

Most of the current innovations occur at the interfaces between the traditional academic disciplines, thanks to cross-fertilization and common understanding of the interdisciplinary issues. The first interface domains and the more mature ones are computer-supported collaborative work (CSCW) and computer-supported collaborative learning (CSCL), which are expressions of the constructivist principle underpinning most of the TEL approaches. The second interface domain is multimedia technology. Ubiquitous access to multimedia streams and synchronous services (including mobile ones), with the necessary quality and continuity of services, are currently popularized by iTunes U and are also especially important in engineering where complex simulations and teleoperation play increasing roles. The third interface domain being currently instrumental in TEL is human-computer interaction (HCI). Investigations are conducted in order to ease the interaction between people themselves, as well as between people and learning resources or services. The current hypothesis is that enhanced interaction and facilitated appropriation of the solutions lead to more opportunities for learning. As a matter of fact, engineering education practice is full of research challenges for the mentioned disciplines. In fact, engineering education practice requires high-level skills, as well as interaction with complex resources and environments.

One of the key issues for the successful development of EER is the establishment of a proper scientific methodology, and the involvement of engineering faculty members, as well as academic recognition. In this sense, higher education institutions are interesting places as they typically host both educational and research activities. As a consequence, all the ingredients for valorizing innovative educational approaches from a scientific point of view are present, especially nowadays with more indexed journals in the field, such as the ASEE Journal of Engineering Education (www.asee.org/publications/jee), the International Journal of Engineering Education (www.ijee.dit.ie), the European Journal of Engineering Education (www.informaworld.com/ejee) or the International Journal of Online Engineering (www.i-joe.org). It is also worth mentioning journals dedicated to e-Learning such as the new IEEE Transactions on Learning Technologies (www.computer.org/tlt), the International Journal of Technology Enhanced Learning (www.inderscience.com/ijtel) or the International Journal of Computers & Education (www.sciencedirect.com/science/journal/03601315).

The progressive establishment of an EER setting at the Swiss Federal Institute of Technology in Lausanne (EPFL) is the result of concomitant actions. It started with a smooth rapprochement of services and units supporting education, evaluation and IT resources. It continued with institutional support for individual educational initiatives. It then became more visible with national initiatives such as the Swiss Virtual Campus (www.swissvirtualcampus.ch) that, despite its failure, had the benefit of establishing a Swiss-wide interdisciplinary community. Then, large-scale multidisciplinary projects started to be supported by both the Board of the Swiss Federal Institutes of Technology and the European Union, with the requirement of bringing together large interdisciplinary teams with a combined research and implementation focus. At that stage, and this is the key enabling factor, the funding became sufficient to offer PhD student positions in TEL Research, which also enables the publication of scientific results in relevant conferences and journals. It is worth mentioning that, in Europe, most TEL Initiatives are project-based and driven by bodies external to the traditional educational institutions. Among the pros of such an approach is the possibility of reaching a significant critical mass and of forming interdisciplinary consortia to handle all the dimensions of the educational challenges and to foster success and visibility. The cons include the difficulty of integrating the results in local institutional policy, knowing that European universities are becoming more and more independent from the national and European governmental education agencies or departments for branding, ranking and efficiency purposes. Because this gap exists between institutional policy and EER practice, innovative educational approaches mainly spread organically through the exchange of best practices between educators and study programs, sometime with students acting as liaison when they enjoy a new practice or technology.

In this paper, the interplay between engineering education practice and professional engineering practice will be illustrated in Section 2 from a TEL adoption point of view. Then, the current challenges tacked in TEL and the potential benefit of Web 2.0 technologies for engineering education practice will be discussed in Section 3. The experiments carried out at the School of Engineering at EPFL to introduce Web 2.0 social software as collaborative workspace and the Community of Practice (CoP) paradigm as a pedagogical scenario in hands-on laboratory activities [4, 5, 6] will be presented in Section 4. Finally, the current investigations on how to turn personal learning environments into powerful support solutions for engineering students will be detailed in Section 5 before the conclusions.

2. The Interplay Between Engineering Education Practice and Professional Engineering Practice

In this section, it is argued that engineering education practice cannot be separated from professional engineering practice. The role of EER is however instrumental in raising awareness and ensuring a smooth and effective convergence of these practices. In other words, EER is an artifact supporting the convergence of engineering education practice and professional engineering practice (itself being influenced by social practice). Without trying to write an historical survey of the progresses in engineering education, it is interesting to look back a few decades ago and to see what solutions emerged and which ones survived in order to support the above claim. Figure 2 shows the main advances in engineering education with indicative dates taken from the first occurrence of the keywords displayed with a star (*) in the title of an IEEE Conference Proceedings paper available in IEEE Xplore.

In the 80's, questions arose regarding the broad integration of the new personal computers and interactive software packages in engineering education. Blended learning and computer rooms were the associated methodological and logistical responses introduced as a complement to the already existing **Face-to-face Instruction** combining classroom teaching, home work and laboratory instruction. Concurrently, the new discipline of **Computer-aided Instruction** emerged beyond the boundaries of engineering education and prototypes of interactive courseware became available. Multidisciplinary investigations were carried out regarding the integration, effectiveness and design of such technologies for education. Educators started to appreciate the difference between teaching and learning. It is worth mentioning that what survives in engineering education from this period from a technological point of view is the use of professional simulation packages (like Matlab™) and computer-aided design ones (like SolidWorks), mainly because **educators** also use them in their own research activities, hence reducing the overheads of integrating them for education. This example shows that it is the actual professional engineering practice that shapes the actual engineering education practice when no institutional constraints force other paradigms.

Then, thanks to the multimedia capabilities of the personal computers, new dimensions were introduced in courseware. **Multimedia Instruction** really became ubiquitous in the 90's, thanks to the worldwide availability of the Internet and its easy Web access. At the same time, the first attempts to implement remote access to both virtual and real laboratory resources were realized for classroom demonstrations carried out by educators and for remote experimentation carried out by students. Again, investigations were carried out regarding the integration, effectiveness and design of such technologies for education. Virtual and remote experimentation became nearly as common as the **Web-based Instruction** paradigm once Web accesses were integrated as standard features in professional software packages used by educators and **practitioners** (such as Matlab™ and LabVIEW®). As well as being useful for implementing new engineering education paradigms, teleoperation appeared to be a new professional engineering practice to be taught. Learning Management Systems (LMS) were also adopted by numerous institutions as a way of enforcing common instructional practices. LMS, which are rather Teaching Management Systems, own their survival to **administrators** and **instructional designers** that rely on them to manage more and more complex curricula designed for more and more students using more and more educational resources.

Later, the greater and faster accessibility of the Internet helped in a better response to the market demand for more autonomous and team-ready employees with the development of **project-based collaborative learning activities**. Virtual and collaborative spaces enabled the introduction of active learning, professional-like knowledge management and teamwork activities in curricula, which spread across distance and time constraints. As in enterprises, among all the developed and implemented solutions, the almost unique groupware solution that survived was the email for asynchronous communication, the phone for synchronous ones, and the campus facilities for face-to-face ones, thanks to their universality and their ubiquity. Again, it was an alignment of the personal and educational practices for both students and educators.

Today, we are moving from a progressive evolution to a hidden revolution for multiple reasons. First, students entering the university are digital natives often with higher technical skills than their educators, who are digital immigrants. Secondly, Web 2.0 technology enables educators to move from blended learning approaches to blended contents (blogs, wiki, repositories) and blended learning environments called personal learning environments [7]. Such environments will progressively replace, or at least complement, LMS in the coming years in a move towards personal and social learning environments [8]. Thirdly, students can access open learning repositories outside their institutions, which is somehow threatening the current institutional models.

This short survey shows that most of the ingredients of blended learning that survived in the education arena were the ones adopted by stakeholders in their professional practices. This influence is however bidirectional. In fact, new educational practices also shape professional practices once young engineers enter the job market or take academic positions. Just as an example, EPFL implemented virtual instrumentation in Switzerland before most enterprises. Later, when EPFL graduates joined industrial R&D departments, they naturally imposed this new paradigm that became common practice. This is a call for a better understanding of the interplay between educational and professional practice in engineering, knowing that EER can play a key role in this cross-fertilization.

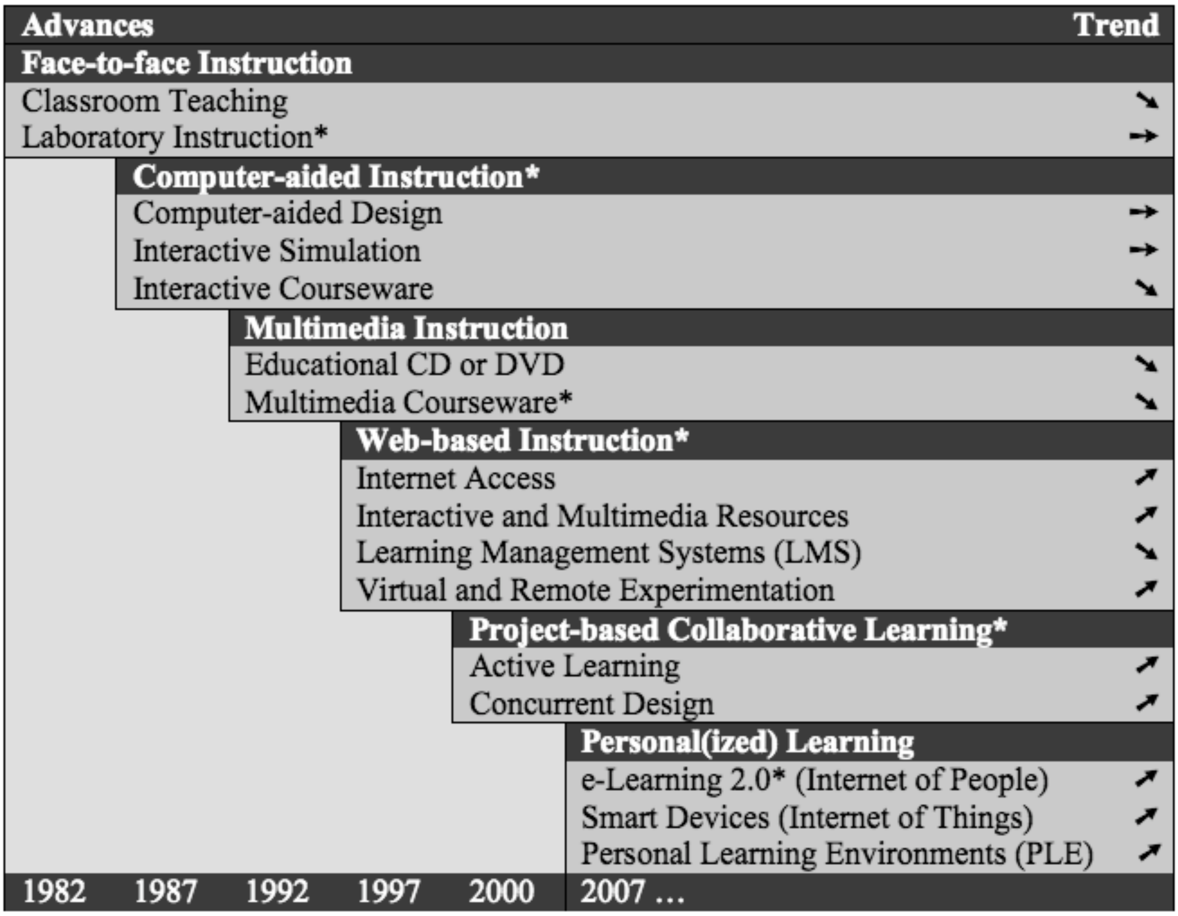

Fig. 2. The educational landscape over 25 years with trends (arrows): From personal teaching (one teacher addressing many classroom students) to personal learning (one learner interacting with many worldwide peers).

3. Technology Enhanced Learning and Web 2.0

Current Challenges in TEL at the European Level

Starting in February 2009 and for a period of 40 months, the European Commission is funding the STELLAR European Network of Excellence (www.stellarnet.eu) as an instrument to unify the diverse TEL communities and to strengthen scientific excellence in TEL. The overall aim of STELLAR is to focus on advanced TEL that engage learners and teachers in new ways of learning in order to change both what it means to learn and what it is possible to learn. Towards this aim, three grand challenges have been identified and are currently tackled by STELLAR: 1) Connecting Learners, 2) Orchestrating Learning and 3) Strengthening Contexts. The research agenda behind **Connecting Learners** derives from the observation that the current opportunities to network with people and to share resources online are changing the way interaction and knowledge are managed and how learning can occur. Replacing the current centralized, static technology-push models with new interactive models that reflect the continuous, social nature of learning requires a radical shift from the focus on knowing what to the focus on knowing how and knowing who. In engineering education, new schemes have to be investigated using Web 2.0 technologies and social networks to enable better interaction between students at various levels, between students and educators, as well as between students and alumni or community members already engaged in professional practices. The research agenda behind **Orchestrating Learning** derives from the observation that situated, collaborative learning clearly demands a new approach to pedagogy, didactics and assessment. The necessity to personalize and analyze the new key abilities and skills required in the knowledge society has become a critical issue in education. The specific characteristics induced by new technologies in teaching and learning are also important issues to be studied. New roles for educators, tutors and even institutions have to be defined taking into account the increasing role of informal learning communities, as well as learning resources and services accessible online. In engineering education, competences management, serious games, flexible curricula design, and personal coaching from online communities have to be further investigated in order to better align educational offers with individual and economical expectations. The trade-off between selfish university branding and philanthropic resources sharing has also to be revisited. The research agenda behind **Strengthening Contexts** derives from the observation that learning has become an integrative part of our life, Consequently, the tools, resources and systems that are used need to be contextualized. In addition, the interplay between formal and informal learning in formal and informal contexts has to be instrumentalized through the use of physical artifacts, mobile devices and the configuration of physical and virtual space, in order to create learning opportunities beyond the traditional institutional boundaries. In engineering education, the transition from institutional LMS to open personal learning environments that better support creativity, the versatility of the new learning schemes and the disappearing IT boundaries all have to be investigated. In such environments, the support for professional-like knowledge management services, concurrent design facility access and opening to the whole Internet of Things (sensors, agents, laboratory facilities) have to be eased to better prepare learners for real professional life and for lifelong learning.

At the intersection of the three TEL grand challenges mentioned above, one can identify Personal Learning (PL) and Personal Learning Environments (PLE) as quite promising but unexplored and unexploited education paradigms. The interplay between PL and PLE is tackled in the ROLE European Integrated Research Project funded by the European Commission for four years, starting in February 2009. PL or self-regulated learning has become increasingly important in educational and psychological research. The idea is to give learners a greater responsibility and control over all aspects of TEL [9], which is beneficial for their actual learning outcomes [10]. Another reason is seen in the advance of life-long learning, and thus, of non-academic learning environments, where instead of instructor- and teacher-orientation more learner-orientation is requested [10]. The PLE is the place where PL occurs and comprises all the different tools we use in our everyday life for learning as defined by Attwell [11]. The wise combination of PL and Web 2.0-based PLE is the cornerstone of e-Learning 2.0 as described below.

e-Learning 2.0

The Web 2.0 buzzword refers simultaneously to behavior and to technology. From a behavioral perspective, Web 2.0 refers to the way that people and businesses embrace the strengths of the Web and use it as a platform, especially for hosting user-populated services and enabling social networking. From a technological perspective, it refers to agile development processes and deployment approaches pulling together features from distributed, independent providers [12]. Any Web user becomes the designer, the administrator and the content provider of his or her own open spaces shared with the worldwide online community. The service provider's role can be identified as the enabler or facilitator in this framework.

The personal learning concept also implicitly refers to multiple dimensions. From an educational perspective, it carries the idea that learning is more effective when self-directed and conducted with the support of a chosen group or communities. From a contextual perspective, it carries the necessity of relying on spaces and artifacts to support face-to-face or at-distance interaction. Any personal learner becomes the actor, the knowledge manager and the content provider of his or her learning activities shared within a learning community. The educator's role can be identified as the enabler or facilitator in this framework.

It is obvious from the above remarks that there is an almost perfect match between Web 2.0 [13, 14, 15, 16] and personal learning if the mediated interaction for socialization in an online community evolves towards mediated interaction for learning. Such an evolution corresponds to the transition from an online community to a learning community, and in some cases to a community of practice. Hence, the distinction between personal learning and social learning is somehow disappearing. As a consequence, Web 2.0 social software has been naturally selected to support personal and collaborative learning in learning communities or in communities of practice. Similarly the Web 2.0 and the Community of Practice (CoP) paradigms have also been considered as new ways to implement personal and collaborative learning in traditional educational settings (academic institutions and corporate enterprises), with a special focus on giving control to the students of their virtual learning environments and on flattening the traditional hierarchical roles existing in education by turning all the stakeholders into learning partners.

If relying on a learning environment (as an experimentation tool) and on a group (as an experimentation context) for learning is considered a constructivist approach, the new paradigm for a learner of shaping his or her own learning environments and his or her own learning communities may be considered as a meta-constructivist approach (by analogy with data and meta-data concepts). In the PLE community, it is stated that the construction of the environment is part of the learning process. In the next section, the way this meta-constructivist approach of e-Learning has been deployed at the EPFL is described.

4. Implementation of an e-Learning 2.0 Approach in Engineering Education at EPFL

Laboratory activities play a key role in engineering education as an active and collaborative learning framework. At EPFL, the automatic control laboratory sessions have been used as a testbed for the implementation and the validation of new learning paradigms and new learning technologies for more than 20 years. These sessions and the associated theoretical course are currently mandatory for students enrolled in the last year of the bachelor program in electrical, mechanical and micro-engineering. Since 2001, all the experiments are accessible locally or remotely for collaborative Web-based experimentation [4].

Between 2006 and 2009, the EPFL has designed an e-Learning 2.0 collaborative learning platform in the framework of an European research project investigating the exploitation of tacit and explicit knowledge in communities of practice (http://palette.ercim.org), as well as the interplay between technology and practice. This development followed a participatory design approach [17] carried out with professional communities of practice that is fully in line with the Web 2.0 development philosophy, as well as with simultaneous engineering practices. It also took advantage of the experience gained in implementing the above-mentioned collaborative Web-based experimentation paradigm. The resulting general purpose social software named eLogbook turned out to be perfectly suitable for implementing an e-Learning 2.0 approach in engineering education at EPFL, and especially in the automatic control laboratory sessions. The implementation objective is twofold. First, it aims at handling the students and the teaching assistants as members of a community of practice interested in laboratory activities. Secondly, it aims at exploiting the social software as a Web 2.0 PLE. After a short presentation of eLogbook, the implementation scenario and some validation results are presented below.

The eLogbook Web 2.0 social software (http://eLogbook.epfl.ch) aims at sustaining collaboration and learning in online communities, and especially in communities of practice, the latter showing interaction patterns that typically evolve over time. It offers community members a networking and communication platform, a repository for sharing and managing resources, a task and activity management system, as well as a community structuring tool allowing the definition of roles and the distribution of tasks. It also provides different types of notifications (via email, or RSS feeds) in order to motivate contribution and sustain collaboration. The design of eLogbook is based on the 3A interaction model [18]. The 3A model accounts for three main constructs or entities: Actors, Group Activities and Assets. **Actors** are entities capable of initiating an event in a collaborative environment. They can be humans as well as virtual agents. Actors can create collaboration spaces where they conduct **Group Activities** to reach specific objectives. In each of these activities, actors can take different roles, each of which consists of a label and an associated set of rights. Furthermore, Actors produce, edit, share and annotate Assets in order to meet their activities objectives. **Assets** can consist of simple text files, RSS feeds, wikis, videos or audio files. In addition, a group activity can possibly include well-defined planning of expected assets with concrete submission and evaluation deadlines, predefined evaluators and submitters. This is particularly useful in project-based learning communities and online educational environments. The model accounts for Web 2.0 features: entities can be tagged, shared, commented, linked together and rated. By design, eLogbook can serve not only as a local networking platform, a repository of assets and an activity management system, but also as an aggregator bringing together content and services from other Web 2.0 applications. The unique feature that makes it suitable for engineering education is the possibility of inviting laboratory experiments or simulation tools as active agents (actors) in the collaboration space. These agents, as any other human participants, can create and reuse assets such as measurements, models or simulation results.

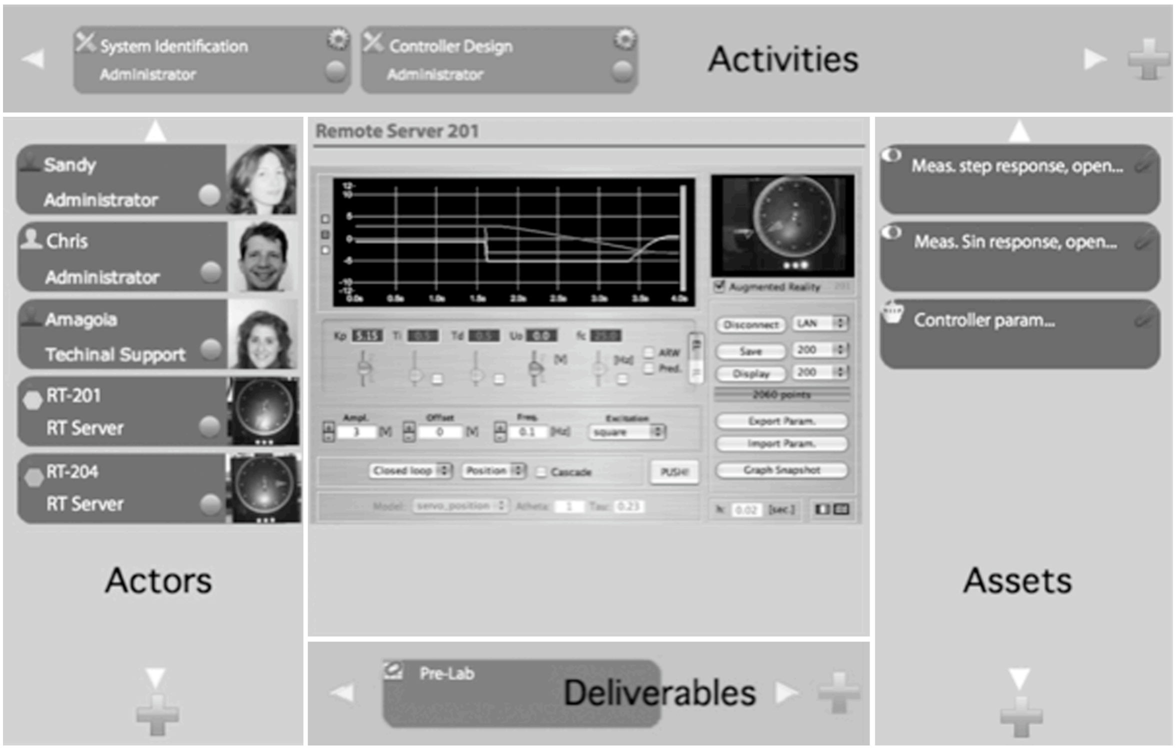

Fig. 3. The eLogbook contextual view showing an experiment as the central element with the related actors (left-hand side area) of the associated laboratory activities (upper area) together with relevant assets (right-hand side area).

The eLogbook social software can be considered as a contextual aggregator and navigator. Its context-sensitive view (Fig. 3) consists of a central element defining the context surrounded by three main regions dedicated to activities, actors and assets respectively. When an entity is selected as the context and displayed as the central element, the surrounding areas are updated to display the entities related to it along with their relations and the associated actions that actors can perform.

The eLogbook social software has already been validated twice in the framework of the automatic control laboratory sessions. First in 2008 with 20 students from mechanical engineering (a subset of a class of 90), then in 2009 with 128 students of the three study programs (electrical, mechanical and micro-engineering) enrolled in the automatic control course. The first validation was mainly carried out to assess the acceptability of considering groups as small communities of practice, as well as the acceptability of eLogbook as a PLE. The second evaluation was mainly dedicated to assess the acceptability of the Web 2.0 features of eLogbook, such as tagging, commenting and rating. The total time dedicated to the automatic control laboratory sessions is limited to 8 hours in the students' schedule. The students only take one two-hour introductory session where the learning objectives and the laboratory environments are presented, three two-hour laboratory sessions or modules where the actual experimentation takes place, and a final oral examination session. The students also are expected to spend an additional 6 hours of personal work. The experimentation sessions can be carried out on-campus at a fixed schedule or remotely at any time. Teaching assistants are accessible at the fixed schedule for face-to-face interaction or online at negotiated times. The central entity displayed in Figure 3 is an Applet used as a Web-based experimentation agent integrated in eLogbook to work with a classic linear controller on an electrical drive located in the laboratory premise (20 such real setups are available for students, 2 of which are visible in the left-hand side column of Figure 3 as invited actors and labeled as RT Server). At any time during the experimentation, the students can save their measurements or controller parameters as assets in eLogbook. An additional SysQuake remote agent is available for data analysis. It can load measurement assets for signal processing and can save data analysis scripts or produced graphs as assets. Private or public group activities or discussions can be created at any time by the students and are linked to a specific context.

By definition, a community of practice is a freely aggregated community whose members can have different expertise levels but who share a common goal. As a consequence, we asked the students to freely aggregate in small communities of one to four members to carry out their laboratory sessions. We also asked them to invite a teaching assistant as an expert member. The role of the teaching assistant was to share his experience in planning and conducting laboratory sessions, as well as to share his experience of the subject matter. To make sure that the teaching assistant could be accepted as a member, no grading duties were assigned to him. In 2008, the students aggregated in 2 groups of four, 2 groups of three and 3 groups of two students. In 2009, they aggregated in 11 groups of four, 14 groups of three, and 21 groups of two students. The log files of eLogbook show that both in 2008 and 2009 more sharing appears in groups with more students. Obviously, 3 experimentation sessions of 2 hours are not enough to develop a full sense of community and develop shared community practices. However, the CoP paradigm strongly increased the motivation and the level of interaction between the students and the teaching assistants, as stated by the latter in post-course interviews.

In the Web 2.0 framework where alternative tools are generally available, assessing the acceptability of eLogbook (or any other tools) can be done by assessing its adoption, i.e., by observing if the tool is used or not. Typically, a tool is adopted if its added value in terms of features (utility) and the quality of its user interface (usability) are high enough. In 2008, only one of the 20 students did not activate his eLogbook account. Six students connected less than 3 times and 13 students connected at least 3 times. It appears that some students with a small number of connections in fact shared the login and screen of other team members during face-to-face sessions in order to work closely on a single computer. The answers to the question of whether direct access to the agents and group activities from eLogbook helped the students had a median of 4.5 on a 7-point preference scale (between 7 for a full agreement and 1 for a full disagreement). This shows that students were quite satisfied with the role of eLogbook as a PLE. The recurrent positive comments given during the interviews and in a questionnaire also support this claim. The average number of assets created by the students was 12.6 and half of them were shared (assets not shared were typically measurements not worth keeping). In 2009, the average number of assets created by students was 9.9. 82% of the students stated in a questionnaire that they had used eLogbook from outside the laboratory premises for remote experimentation. The statement that conducting experimentation remotely is useful got a score of 5.8 on the 7-point preference scale.

Web 2.0 features like tagging and commenting support the students' motivation and collaboration by developing a sense of belonging to the group and awareness of ongoing activities by team members. Tags also help to run targeted searches of entities in the eLogbook repository. In 2009, a total of 204 tags were used 522 times. 24% of the students commented on their assets. Students tagged an average of about 10% of their assets, irrespective of the size of their group. The rating feature was almost not used, mainly because uninteresting assets were deleted. Group of four, three and two students created an average of 2.9, 1.4 and 0.8 private chat discussions, respectively. This makes sense, as it is easier for a group of two students to find opportunities to talk face-to-face on campus than for a group of four. More 2008 evaluation results are published in [18].

Obviously, the application scope of Web 2.0 social software goes beyond collaborative learning in engineering education as demonstrated by our experiment carried out at the EPFL. It is useful for collaborative learning in any online community, as well as for more broad knowledge management activities in institutional and corporate settings.

5. Perspectives for PLE and Learner-driven Recommendation

New research questions emerged from the introduction of Personal Learning Environments (PLE) and from the orientation towards personal and social learning. One should mention that personal and social learning already occurs, but outside the radar of the educational institutions. Hence, when one talks about moving towards personal and social learning, this means to start to recognize its existence, to understand it and possibly to exploit it to better support students with personal learning environments.

The specifications of the ultimate PLE are still fuzzy. A better understanding of the social and informal learning practice has first to be obtained. From preliminary testbed analyses conducted at the European level, a few hints can already be given. First of all, a PLE will not be a monolithic or a single environment (otherwise it is a LMS). It is more a set of support services able to be integrated on-demand and in-context. The corner stone of this PLE will be a search engine capable not only of finding Web pages, but also relevant content, communities and services. The existence of the PLE itself could be made possible by shareable configuration files enabling, at a specific time and in a specific context, one to bring all the necessary services at the learners' disposal. Ideally, these configuration files should be compatible with future Web browsers, which could be considered as PLE Players. As opposed to the current prototypes, it would not be necessary for the future PLE to graphically integrate all necessary services in a single Web page (working on a computer, most users concentrate on one or two application windows). So, the PLE should enable data sharing between relevant services made available by various providers. Such a scheme can be defined as a functional integration in depth, instead of a graphical integration in width. In addition to services, integration of communication and interaction devices may also be necessary (a video player, a mobile phone, a tablet PC or laboratory experiments are just a few examples). The PLE could be predefined and used as it is for a period of time. It could also be a live environment which is changing at different stages during it actual usage. As PLEs may require quite a high level of autonomy to be assembled and customized, not all learners could be targeted as PLE users. An alternative scenario is also to target educators as PLE users and PLE configuration providers. One can imagine educators defining and sharing PLE configuration files to propose to colleagues or students a nominal PLE to be later adapted to personal learning styles or needs. PLEs can be considered as artifacts to cross traditional boundaries existing between institutional and corporate communities or systems, to bring worldwide knowledge and service consumers and providers together, as well as to bring contextual open content and free services in customized user spaces.

Moving from learning management systems towards personal learning environments is a move from learning content to learning context. Instead of packing learning objects for students, PLEs are a place where recommended learning services are mashed-up by the learners him or herself following recommendations given by peers and, hopefully, in the near future also by educators or institutions. Depending of the resulting assembly, a different learning context is available and different learning objects and online communities can be accessed through the available services. As a consequence, the key issue in deploying PLEs is to provide adequate recommendation, knowing that recommendation can be provided by a service being itself part of the PLE.

By letting users invite peers, define activities and manage knowledge assets, the eLogbook social software introduced in the previous Section can be considered as a rich prototype of PLE. Its capability to invite smart devices like remote experiments [19] or agents like simulation widgets enables functional mash-up [20]. Hence, it is well suited to support engineering education. Following the experience gained in supporting the evolution and the various learning activities of communities of practice, at least three fundamental entities should be recommended and mashed up in PLEs, i.e. actors, activities and assets which are by the way the three pillars of the underlying 3A interaction model of eLogbook. The recommendation should also be contextual with respect to one of the three entities in the sense that, if a given activity is chosen, the recommended actors and assets should be adapted accordingly [21]. The recommended actors can be people, services, widgets, agents and things. Recommended activities can also be spaces or communities related to the central context. The recommended assets can be any type of documents, multimedia resources, discussions threads, wiki pages or blogs, as well as RSS feeds or PLE configuration files. In a PLE, recommendation should have many additional features compared to eCommerce ones. First, recommendation should be provided by mining, filtering and sorting entities located in various online repositories and communities to enhance its value. In this perspective, we are currently enabling the import of peers from other social software in eLogbook (such as Facebook or LinkedIn) and the aggregation of feeds from other shared spaces (for accessing external assets, such as slides from SlideShare). Aggregation is already common, but recommendation based on aggregated data is specific to the discussed PLE framework. Also, the recommendation should be driven by the learners, which should be able to give preferences and to reject or reorder proposed entities. In that sense, PLE-based social learning differs from adaptive learning where learning needs are automatically estimated by an ad hoc system.

In order to enable competence management and life long learning, we are currently expanding the 3A interaction model of eLogbook to 5A (Fig. 4); the two additional "A"s being abilities and aims. Then, any of the five entities (actors, activities, assets, abilities and aims) can be chosen as a context for recommendation of all the other related entities. As example, one can select "teamwork" as an ability (soft skills) and get recommended activities available worldwide (courses, modules, reading, …) to develop teamwork skills, recommended assets (reading, videos, …), as well as recommended educators or peers to interact with. The aims (or objectives) are added to introduce a time dimension in the recommendation, such as progressing from the bachelor to the master level. Thanks to this additional dimension, it is possible to envision a recommendation of a sequence of activities with, possibly, successive PLE configurations as recommended assets. PLE configurations could be considered as future learning objects, which should describe the services to be mashed-up in the PLE and the way they interoperate. The idea is to enable educators or peers to exchange or even recommend PLE configurations suitable for a given learning activity.

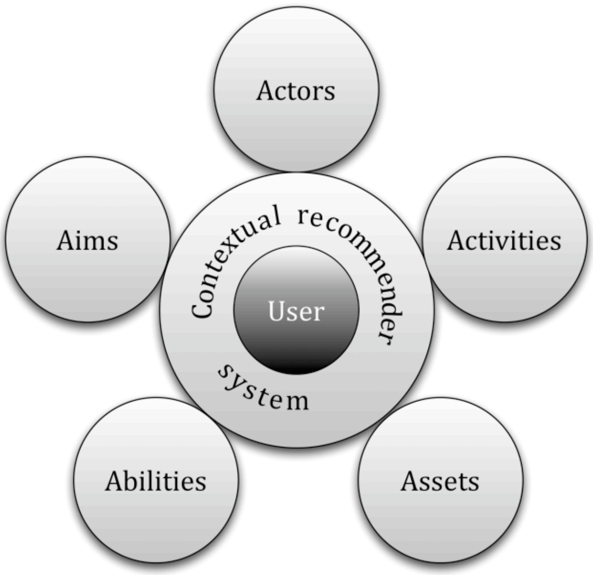

Fig. 4. The 5A interaction model for contextual recommendation.

Trust and reputation are important challenges to tackle in order to successfully support PLE-based social learning. In fact, when searching for relevant entities, learners have to expose somehow their current knowledge level. So, they should trust the service that is getting and possibly archiving such information, which is typically more sensitive that basic Google keyword searches or eCommerce queries. The learners also have to trust services and resources providers, as well as community members they interact with. In the traditional learning context, this reputation is given by the educational institution and is indirectly shared by its educators and its resources. As a consequence, a global trust and reputation model should be built on top of the PLE recommendation services as an alternative to institutional reputation. Last, but not least, micro-payment or brokerage mechanisms should be designed and implemented as incentive for people to share services or competences with other learners.

6. Concluding Remarks

In this paper, it is argued that the interplay between engineering education practice, professional engineering practice and EER is instrumental in supporting the adoption of new learning approaches and TEL solutions. In addition, it is noticed that EER only differs from more general education research by the fact that it is carried out in a real-world context by engineering faculty members. This singularity is however essential in promoting and enabling the adoption of new practices by peers, as it is easier to trust members of a community we belong to.

European research projects have been instrumental in establishing an interdisciplinary community, which is operating outside the formal project structures as a community of practice supporting advances in technology enhanced learning research and practice.

Currently, there is a new trend in investigating and better supporting personal learning, with potentially a significant paradigm change in education in general and in engineering education in particular, as the latter targets autonomous students developing high-level skills. Nowadays, educators act as aggregators and recommenders for curricula, resources and tutors in traditional institutions. In the future, they could concentrate on recommending PLE configurations and open PLE services; the final aggregation being carried out personally by the learners in an open worldwide social learning space. Personal learning is a paradigm that gives more leverage to communities. If institutions recognize this trend, there is a possibility of blending formal and informal learning. Recommendation, trust and reputation are the three pillars and the three challenges in the PLE-based social learning realm.

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Captions for figures

Fig. 1. The Interdisciplinary nature of TEL in EER with key challenges located at the interfaces between traditional academic disciplines.

Fig. 2. The educational landscape over 25 years with trends (arrows): From personal teaching (one teacher addressing many classroom students) to personal learning (one learner interacting with many worldwide peers).

Fig. 3. The eLogbook contextual view showing an experiment as the central element with the related actors (left-hand side area) of the associated laboratory activities (upper area) together with relevant assets (right-hand side area).

Fig. 4. The 5A interaction model for contextual recommendation.

Brief biographical sketch of up to 100 words

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