The technological dimension of Educational Technology in Europe

Abstract. The technological dimension is critical for sustainable development of technology-enhanced learning. This paper shows some of the main technological trends and issues of the European landscape of research and innovation in educational technology. Although several innovative technologies (tools, architectures, platforms or approaches) emerge, such as intelligent support to personalization, collaboration or adaptation in mobile, game-based and inquiry learning, other trends show the need for a more balanced and scalable view in which all dimensions are taken into account. The support of the life cycle of technology-enhanced significant educational scenarios puts more emphasis on orchestrating complex educational ecosystems, as well as taking into consideration all stakeholders, especially educational practitioners.

Introduction

Educational Technology (ET) is globally considered as a multi-disciplinary field, in which Information and Communications Technologies (ICT) are supposed to enhance the teaching and learning processes, i.e. to contribute to the Technology Enhanced Learning (TEL). From a techno-centric point of view, education can be considered as yet another application domain; while from an educational or pedagogical angle, ICT is often viewed as a simple instrument that serves educational objectives. According to one approach, the objective is to adapt, design and build new technologies for education, while other approaches aim to follow the "new" technologies that emerge and try to use them in the best possible way.

This paper aims to show the role and evolution of the technological dimension in education according to the aforementioned approaches through some significant facets, putting more emphasis in some differentiating European features, even if the general trends are global. Of course, this technological dimension is considered in connection to the rest of dimensions mentioned in (Trenton, 2007), regarding sustainable use of educational technology and innovation.

The European landscape of research in Educational Technology

The Technology Enhanced Learning (TEL) strand of the European Union Framework Program (FP) has shaped the evolution of ET research in Europe during the last decade, besides the national R&D, as well as the industry-oriented programs. The research community has been reinforced especially through four Networks of Excellence (NoE), i.e. *Kaleidoscope* (Kaleidoscope, 2011) and *Prolearn* (Prolearn, 2011) in FP6, and *Stellar* (Stellar, 2011) and *Gala* (Gala, 2011) in FP7. The first two NoE have resulted in two associations that are currently managing their legacy, i.e. *TeLearc* (Telearc, 2011) and *Eatel* (Eatel, 2011) for *Kaleidoscope* and *Prolearn*, respectively. Although there are no neat frontiers among associations and the corresponding NoE, *TeLearc* and *Eatel* reflect the two approaches mentioned in the introduction, i.e. whether the driving force lies in the educational needs or the technological affordances of new artifacts. Also, the specific calls on TEL projects (TeLearn-Digicult, 2011) resulted in 25 funded projects that were initiated between February 2008 and October 2010.

From the analysis of the aforementioned projects and associations, one can detect the main research trends that form part of the European Union (EU) strategy in TEL. The focus of research aims to promote several key aspects of the teaching and learning processes, such as, personalization, adaptation, game-based, as well as lifelong learning in which learning meets work. These strategic priorities have motivated or taken advantage of work in the technological dimension, as e.g. architectures and systems for collaborative learning, immersive environments, Semantic Web technologies, or intelligent agents that take into consideration the traits of human-computer interaction or human-to-human interaction through computer networks. On the other hand, the new call 8, scheduled for 2012, includes a new strand on "*Supporting European wide federation and use of remote laboratories and virtual experimentations for learning and teaching purposes*".

Among all these funded projects, we could highlight two of them that show a significant part of the main technological issues, as related to the general strategic priorities, i.e. ITEC (Itec, 2011) and SCY (Scy, 2011).

The first project, ITEC (initiated in late 2010), aims to "*design and build scalable learning and teaching scenarios for the future classroom*", i.e. it tries to close the gap between research and practice of innovative use of ET in classrooms.

Instead of proposing yet another set of new learning technologies, the project chooses the path of building meaningful scenarios through the selection, registration, categorization, formal description and combination of available resources, either tools or static resources. Thus, in this case, the technological dimension is considered as a vehicle to support the work of the stakeholders, and especially teachers. However, such an approach requires a clear understanding of how to describe resources and scenarios in order to satisfy two competing requirements; exploiting ICT capabilities, using a computationally interpretable way through learning design or semantic technologies; and enabling the appropriation of these descriptions by the stakeholders.

Although the project is still in its early phases, it can be perceived that there is a special focus on scenarios, as a means to capture needs from all dimensions, including technology, as well as a way of producing technology-enhanced activities. The formal, semantic description and sharing of these scenarios is envisaged as a major technological challenge. On the other hand, special emphasis is put on the interoperability and seamless integration of tools and services that would enable the pedagogical scenarios.

Support to science inquiry learning, or "*learning by designing artifacts*", is the main objective of the second project, SCY (initiated in 2008), which employs the novel concept of Emerging Learning Objects (ELO) as learning artifacts produced by the students within authentic scientific missions.

A major technological advance of this approach consists in the efficient management (social tagging, indexing, smart retrieval, etc.) of such objects through a shared repository. The underlying agent architecture (Weinbrenner, et al., 2010) allows managing ELOs, traits left by the learners involved in the missions, and supports scaffolding of the knowledge construction process, at both individual and group levels. These achievements show that intelligent scaffolding is possible and meaningful in authentic contexts, although these long-term contributions of artificial intelligence to ET still need to deliver more concrete results.

On the other hand, a technological decision of the project was to produce a "*flexible, open-ended environment – called Scy-lab*" in which missions take place. As it can be depicted by the specification and manual deliverables, the overall environment was designed in order to support the concrete innovation, i.e. the inclusion of the ELOs, and therefore the system is mostly self-sufficient. On the positive side, the underlying architecture is flexible and scalable, while on the other hand several existing tools could be re-engineered and adapted to the new environment. However, the technical decisions do not foresee a sustainable exploitation of the environment, since slight perturbations of the technological context may require major technological changes, especially with respect to the unifying interface or the design and evaluation aspects.

Another significant aspect that should be taken into account corresponds to the current work of the *Stellar* NoE (initiated in early 2009) with respect to its great challenges and the prospection of future research areas and tensions through a Delphi study, which goes beyond the European context.

On the one hand, three themes have guided the great challenges roadmap, i.e. "*connecting learners; orchestrating learning; contextualizing virtual learning environments and instrumentalizing learning contexts*". Technology plays a major role in all three great challenges, since it draws on the need to: support collaborative learning (CSCL) eventually in a Web 2.0 (social) or Web 3.0 (semantic) environment; bring together activities, tools, roles, etc. in an integrated and eventually computer interpretable form; or bridge the gaps between formal and informal learning, face-to-face and virtual learning, etc. providing seamless flows of activities based on mobile computing or virtual learning environments.

The Delphi study, based on a wide spectrum of international experts in ET, (Kaendler et al., 2011) has already revealed eleven important areas and five tensions that affect most of the research areas that are aligned with the aforementioned great challenges. Besides the technological support for collaborative and personalized learning, there is a lot of emphasis on the integration and interoperability technological issues, especially when several types of learning need to be interweaved in a seamless way.

Finally, standards are still considered to be an important cornerstone of the European perspective and therefore important work has been realized with respect to specific ET standards, mainly those promoted by the IMS Global Consortium or the general technological standards, mostly those maintained by the WWW consortium.

Some trends regarding the technological dimension

Besides the general elements promoted and reflected in the European Union research programs, some other particular trends can be observed.

Scripting, viewed as *Learning Design* (Conole, 2012) in other contexts, has been especially prominent in European ET research and practice, mostly in CSCL (Weinberger et al., 2009). This tendency also had its technological counterpart in Educational Modeling Languages (EML) and the associated authoring tools, as a means to model teaching and learning processes, similarly to the general Business Process Languages (BPL). The well-known IMS-LD specification (IMS, 2003) was based on a proposal by the Open University of Netherlands, and generated a lot of expectations at a European level, since it allowed for an interoperable modeling of activities, rather than resources, which could be eventually interpreted and executed in computational platforms. Although the specification has not been widely adopted by the community, its advances and retreats still reflect the vivid debate on the role of instructional design and its co-existence with constructivist approaches, or the ways and degree that flexible and adaptive scaffolding and scripting could be enforced through technology.

Besides learning design, the European ET field has also been sensible to the general technological trends for sustainable and global services, especially at the higher education and professional lifelong learning domains. In this sense, federated systems of content repositories (Ternier et al., 2009) or remote laboratories (Lowe et al, 2009) have been developed in order to foster sustainability and global use. These advances show the increasing trend towards service-oriented computing (and recently to cloud computing), loosely coupled architectures and integration through open and standard protocols in the field of ET.

On the other hand, Learning Management Systems (LMS) in TEL have reflected the general trend of Content Management Systems (CMS) and responded to the need for course design and deployment, especially for distance education. The open-source *Moodle* platform has recently dominated higher education, as compared to proprietary systems, such as *Blackboard* or *WebCT*. However, there is a general debate in both educational and technological terms, regarding the necessary balance and co-existence of such centralized

LMS-based solutions, Web 2.0 tools that evolve and get adopted in a much faster pace, or specific ET legacy tools that have been shown to be successful. The initiative by the Open University, UK to integrate VLE like *Moodle*, third-party Internet-based tools such as *Google Apps*, and other social media is a clear example of such an effort to get the most out of all these alternative solutions in a sustainable and integrated way (Kukuska-Hulme & Jones, 2011).

Even if the list of technological challenges in ET can be too long, we should pay specific attention to the increasing number of technological artifacts that are or could be present in the physical classroom, such as interactive digital boards, tablet or laptop PCs, smart phones, or even other tangible elements. This myriad of elements opens new opportunities for interaction, monitoring and scaffolding but also places new challenges towards the orchestration of technology-enhanced classrooms (Dillenbourg & Jermann, 2010). This last observation revives the need for technological support (authoring, deployment and monitoring tools) to teachers and instructional designers in these complex ecosystems (Dimitriadis, 2011).

Conclusion

According to Trentin (2007) the technological dimension, as related to sustainability, is typically overemphasized and therefore it absorbs too many resources, typically at the cost of the pedagogical dimension. Creating the necessary conditions, from a technological point of view, in order to achieve increased sustainability of ET is still a challenge.

This paper did not aim to provide a complete view of technological challenges in ET in Europe. Instead, it strived to emphasize some of the singular initiatives and trends that can characterize the European landscape of research and innovation. The support of the European Union, as well as the adoption of standards that promote interoperability, is a necessary condition for continuous and sustainable technological innovation. Also, the rising use of intelligent agents may advance the field in terms of enhanced personalization, adaptation or scaffolding.

However, focusing on significant educational scenarios, which can be formalized, easily designed and enacted in computational platforms, provides a more balanced attitude. Matching the affordances of existing technological artifacts with the knowledge, beliefs and goals of the educational practitioners (Chen, Looi and Chen, 2009) shifts the attention to the real educational context. At the same time, the design of new innovative tools and platforms, or the rapid adoption of the ever-changing general technological gadgets, should reach equilibrium with the selection and co-existence of adequate tools and platforms, which enable the enactment of the aforementioned significant educational scenarios. The support to teachers for an efficient orchestration of the complex classroom ecosystem could be eventually one of the key aspects for a sustainable use of educational technology in an innovative way.

Overall, this paper suggests the adoption of a more balanced view of an eventually trans-disciplinary field in which technology is designed, used and evaluated within an inquiry cycle (Gómez et al, 2009), and all facets are considered in a holistic way.

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