This is a paper presented at NGL 2012, Next Generation Learning Conference, February 21-23, 2012, Falun, Sweden.

Citation for the published paper:

Daniel Spikol, Peter Bergström, Johan Eliasson, Jalal Nouri, Anders D. Olofsson, J. Ola Lindberg
Bridging the Distance from Research to Practice: Designing for Technology Enhanced Learning
Abstract
A grand challenge for educational research is to remove its weak link to practice. One of the strategies to confront these challenges can be through the use of Design-Based Research (DBR). A DBR approach includes working iterations of design, implementation and evaluation in real world learning contexts, making it especially suitable for research in Technology Enhanced Learning (TEL).

This paper describes and contextualizes a workshop that points out the need to examine different design approaches and digital technology tools to explore TEL in educational practices. Since the goal of the workshop is to use multidiscipline perspectives of education and didactics (ED), computer science (CS), interaction design (ID), to show the complexity for supporting next generation learning, these perspectives will in the paper be described and put in relation to each other. What research questions within and in between the three perspectives should be included in a DBR-approach in order to inform and facilitate TEL-practices. In the end, of the paper a multidisciplinary DBR-approach allowing a more holistic understanding of educational practices using TEL will be argued for.

Keywords: Design-based research, Interaction Design, Education, Computer Science, Technology-Enhanced Learning

Introduction
One of the fundamental challenges for educational research aimed at understanding and developing the adoption and use of Technology Enhanced Learning (TEL) in schools is its weak link to practice, and the obstacles for practice to build on research. Design-based research (DBR) attempts to meet these challenges as it seeks to develop more general theories and locally valuable learning designs, theory-based design, and practical enactment of these designs (The Design-Based Research Collective, 2003). The DBR approach includes working iterations of design, implementation and evaluation in the real world learning contexts, making it especially suitable for research in TEL (Mor & Winters, 2007).

This paper functions as a framework to describe a workshop arguing for the need to examine different design approaches and tools to explore and promote innovative TEL practices along with theoretical concerns. The goal of the workshop is to use multidiscipline
perspectives of education and didactics (ED), computer science (CS), interaction design (ID), to explore the complex issues to support next generation learning. The workshop will be researched-focused, meaning elaboration on how it will be possible using a DBR-approach to gain a deeper understanding of in what way(s) TEL can be used in teaching and learning.

Such focus will require highlighting core research questions within and between the three perspectives should be included in a DBR-approach in order to inform and facilitate TEL-practices. It will also be practice-focused. The questions to ask in a DBR-approach shall be addressed by examining the current state of the art learning tools (e.g. Course Management Tools, Mobile Tools and Social Media).

By that the workshop aims to envision research-based future learning scenarios that add value to the practice of education. The main outcome of the workshop is to identify key themes for further research and discussion, which can be further developed to support and improve the design, implementation and sustainability of TEL research to be used in educational practices.

In order to put this workshop in the context, below we will as a conceptual framework in short outline both some core ideas of DBR is understood and the three perspectives of education and didactics (ED), computer science (CS), and interaction design (ID) respectively. Each perspective will be described in relation to design for TEL. These multidiscipline perspectives will then be put in relation to each other by pointing out the overlaps between them and in terms of some examples of joint research questions.

Finally, we will try to bring the three perspectives together to investigate the possibilities to set up a multidisciplinary DBR-approach allowing us as researchers to, by asking productive and multidisciplinary impregnated questions, construct a more holistic understanding of educational practices using TEL. The aim of the workshop is to create a common understanding that can function as a foundation for a continuously more advanced design principals to guide the further design, development, implementation and use of TEL in education. In the author’s opinion it is of key importance to close the gap from research to practice, a bridge between researchers, teachers, educational technologists and students. This bridge is essential for exploring and developing education and learning for tomorrows TEL-practices.

**Design-based Research**

Design-based research (DBR) is said to entail a series of approaches with the intent of producing new theories, practices and artefacts that account for learning and teaching in educational practices. For example, van den Akker (1999, pp. 3-5) identified four sub-domains of DBR: curriculum, media and technology, learning and instruction, teacher education and didactics. Such approaches to design-based research separate instead of cultivate its interdisciplinary nature. However, it is argued, that a particular design intervention is not simply intended to show the value of a particular curriculum in a local setting but also to advance a set of theoretical constructs (Cobb et al., 2003), to identify reusable design principles and design patterns (Reeves, 2006). Essentially, design experiments are developed as a way to carry out formative research to test and refine educational practices based on theoretical principles derived from previous research (Collins et al, 2004). According to Collins and colleagues (2004), what characterizes design-based research is the process of progressive refinement, which involves putting a first version of a design into the world to see how it works, followed by iterative revisions based on experience.

Design-based approaches in educational research grew to large extent out of criticism from numerous researchers, practitioners, and
policy makers claiming that the findings from educational research have little impact on practice or on the evolution of theory (Collins et al, 2004; Brown, 1992). Ann Brown (1992), one of the scholars that introduced design-based educational research, argued that we should question to what extent we are driven by a pure quest of knowledge, and to what extent we are committed to influencing educational practices.

Against this background, DBR methods are suggested to compose a coherent methodology that bridges theoretical research and educational practice (The Design-Based Research Collective, 2003). This bridging is facilitated by the fact that the methods are grounded in the needs, constraints and interactions of local practice, ensuring to higher extent that the research outputs have bearing on educational practices. DBR envisions that researchers, practitioners and learners/users work together with the goal to produce or facilitate a meaningful change in contexts of educational practices. As such, participatory design methods are frequently utilized in the field of TEL (Mor & Winters, 2007).

**Education and Didactics**

An important aspect of education and didactics in relation to design of TEL-activities in schools and universities is to “focus on creating rich and innovative learning experiences, as opposed to simply developing instructional products through staid processes.” (Hokanson, Miller, and Hooper, 2008, p.37). The design of the TEL-activities shall within this perspective preferable be combined, or interwoven, with an understanding of the possibilities provided by the design behind the technologies used and its intention of what kind of teaching and learning interactions in classrooms and online contexts to facilitate (see further Olofsson & Lindberg, 2012).

An educational and didactical perspective provide, in some difference to the computer science or interaction design-perspective, a specific focus on questions concerning like for example course design, course planning, assessment and evaluation in relation to design of TEL-activities in educational practices (see for example Bergström, 2010; Lindberg, Olofsson & Stödberg, 2010; Olofsson, Lindberg & Hauge, 2011). Here teaching and learning through digital technologies is outlined as aspects of design with regard to the multi-dimensional and multi-relational link evolving from the triad teacher-student-content.

By that, the educational and didactical perspective can be said to embody the potential to extend the design processes aligned with TEL into interpersonal activities within the educational practices. It provides insight in the educational processes and by that a foundation for setting up innovative and creative opportunities for learners to experience, to explore, and to develop new knowledge’s and skills through technology. Design informed by educational and didactical thinking has in addition the potential to provide teachers with ideas and possibilities how to create and continuously develop sustainable TEL-environments and inherent activities such as assessment and evaluation.

**Computer Science**

The role of computer science in respect to educational practices can be summarized by a 1945 article by Vannevar Bush for the *Atlantic Monthly* magazine that extolled the virtues of augmenting man's power of the mind, not just his physical abilities. He envisioned the concept as follows: “A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory” (Bush, 1945, p. 5).

Thirty years later, Alan Kay and Adele Goldberg at the Learning Research Group at
Xerox PARC introduced the Dynabook concept. They envisioned the Dynabook, which was the forerunner to the modern laptop and tablet, as something that can be owned by everyone and that has the power to handle all of its owner’s information needs (Kay and Goldberg, 1977). They positioned the concept as a dynamic medium for creative thought, a self-contained knowledge manipulator in a portable package, the size and shape of an ordinary notebook. In the early 1990’s, Mark Weiser and colleagues extended the Dynabook beyond the idea of a single book-like computer. The aim of Weiser’s ubiquitous computing was to push computers into the background in order to make individuals aware of the people at the other ends of the computer links (Weiser, 1991).

An interesting theme across these historical visions of the future is the common belief by these computer scientists that computers can be used to improve human intellect and communication, to be understood as the core of values of TEL within this perspective. These technologies can be seen to be influencing the world we live, educate and learn in, more than any recent modern digital technology.

**Interaction Design**

The daily use of personal information devices for intellectual, information and entertainment activities can be seen as one aspect of the changing nature of teaching and learning practices. Additionally, the widespread use of these devices is changing how people, especially children, learn because more technologies are assimilated into their everyday lives (Price and Rogers, 2004). The proliferation of these personal devices has challenged interaction design to look beyond the role of the user sitting in front of the screen and reflecting on the task to engaging in the everyday practice of work, education, and life.

Interaction design can be understood as the process of designing interactive systems. Interaction design research then is about understanding the interaction design process and building theories and methods for designing interactive systems (Rogers, 2009). As comparison to human-computer interaction research has a focus on evaluating, rather than designing, interactive systems. Interaction designers may work in cross-disciplinary teams in phases of studying current practice (to frame the design problem), sketching and prototyping (to envision possible designs) and testing (to evaluate design alternatives). The way of working is typically iterative in going back and forth between these three phases until at least one feasible solution to the design problem can be presented. When framing the design problem by studying current educational practice no theoretical framing is required. Additionally the criteria for evaluating a design suggestion are to what extent it solves problems in current educational practice. In contrast interaction design in TEL research is framed by learning theories and design suggestions can be evaluated against learning goals. This might be the main difference between interaction design for TEL and interaction design for work practices and everyday interactive products.

**Productive Overlaps**

The development of digital technologies has led to a large overlap between education and didactics, computer science and interaction design. This overlap has resulted in diverse ICT for education, teaching, and learning that include intelligent tutors, computer aided instruction, computer adaptive testing, teachable agents that explore how artificial intelligence can support learning activities. For example computer science has developed different systems that provide tools for creating, sharing, and managing collaborative information for the communication, information and knowledge management. In addition the development of digital technology devices that range from smart phones, PCs to interactive whiteboards that are commonplace in education. What is interesting to point out is
that although many aspects of our knowledge societies have easily made the transition to use of these digital technologies, educational practices and related teaching and learning activities is moving slowly if not getting a failing grade (compare Reeves, McKenney & Herrington, 2010). For example Erstad and Hauge (2011) argue that the adoption of digital technologies in schools open up for new and exciting endeavours but at the same time that there is no guarantee at all that digital technology-oriented teaching- and learning activities will take place just because the classrooms are filled up with digital learning tools.

One question that here demands attention and consequently needs to be answered by researchers and practitioners is what can be done to change what right now seems to be the situation in many educational practices implementing and using digital technologies for TEL-activities? How will it be possible to gain knowledge and understanding in order to create teaching and learning activities supported by digital technology that in fact makes a positive difference for the learners? That makes them more knowledgeable and skilful? To make them ready for both participate in, and contribute to, the society?

<table>
<thead>
<tr>
<th>Interaction Design and Computer Science</th>
<th>Computer Science and Education and Didactics</th>
<th>Education and Didactics and Interaction Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>How can we describe current practice?</td>
<td>What new approaches can be developed to design TEL systems that consider more than the human and social issues along with the technical?</td>
<td>How can interactive systems be designed that support rather than distract students from the learning goals?</td>
</tr>
<tr>
<td>What are the implications for design of an interactive system from descriptions of current practice?</td>
<td>How can we design and implement educational experiences supported by computing that take into consideration the different roles and needs of learners, teachers, and infrastructure?</td>
<td>How can interactive systems be designed and evaluated to align with learning goals?</td>
</tr>
<tr>
<td>How can theories, methods for developing interactive systems support the design process?</td>
<td>To explore the implications of these different technology design approaches for the development computing applications for TEL.</td>
<td>How do we design computer based learning tools for peer-oriented formative assessment?</td>
</tr>
<tr>
<td>How can the content, techniques, tools and materials structure the design process to support the design of TEL?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How can we integrate educational theory, computer science and ID-theory in order to gain deeper understanding of designing for today's TEL-classrooms?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How can we evaluate interactive systems against a background current educational practice and use?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How can sustainable TEL-activities be designed and implemented?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Examples of research questions in a multidisciplinary perspective DBR-approach
Twenty years ago, Kaput (1992, p. 515) argued, “the limitations of computer use in education in the coming decades are likely to be less a result of technological limitations than a result of limited human imagination and the constraints of old habits and social structures.” In line with the considerations addressed above and in line with Kaput we will here argue that different approaches need to be explored to promote innovative educational practices supported by digital technologies and carried out through TEL. To make that happen it is our opinion that the education, the interactions, and the digital technologies need to be designed together in order to support human knowledge acquisition for successful learning experiences and practices or usable systems.

To be able to design from a multi-disciplinary perspective and to learn from the design we mean that adoption of a DBR approach that integrates the perspectives of education and didactics, computer science with interaction design as partners for succeeding with needed human innovation in TEL will be fruitful. To us such an approach provides a possibility to gain deeper understanding of educational practices of today, their complexity and potential to facilitate teaching and learning activities in digital technology-rich environments. Results drawn from the use of DBR will in addition have the potential to provide important insight in how to design for teaching and learning with digital technology that are taking place not only in expected but also in unexpected ways. A design that is sensitive to the learning activities and its goals. A design that provides the teachers to by themselves elaborate upon the design in order to even further facilitate TEL-activities in the educational practices (compare Fischer & Giaccardi, 2006; Fischer, 2007).

To be able to carry out DBR that includes all three perspectives of education and didactics, computer science, and interaction design in one single research approach we will argue for that the initial phase should be about addressing a number of key questions that will guide the design process to come. That there is a need to put together the perspectives in pairs of two and to identify what kind of research questions that cut through them both.

In Table 1 below we have addressed some examples of research questions that we will argue the perspectives have in common when designing for TEL in educational practices. In the final section of this paper we will then try to point out what a DBR approach aligning the three perspectives can contribute with and how it has the potential to bridge the distance between research and practice.

ED, CS and ID – Towards a fruitful combination

Learning science has a long history of cross and multi-disciplinary work across education and didactics, computer science, psychology, interaction design and other fields (Sawyer, 2006). DBR has provided theories and methodological approaches that provide a framework for investigation and the production of artefacts. But, many theoretical and practical challenges remain from the wide spread adaptation of digital technologies in school and at home, the limited innovation in the use of these digital learning tools in practice, and the difficulty in providing clear research findings. Therefore, we argue for a different approach that embraces three perspectives, that argues for a shift in design thinking to designing experiences and social artefacts that can make sense to users and their communities (Krippendorf, 2006). The questions raised in Table 1, begin the sense making process that can bridge the distance from research to practice by enabling a discursive approach.

When elaborating on design in general, Löwgren & Stolterman (2004) emphasizes the importance of designers knowing the design material well in order to work with its qualities. In this line, the same authors argue that design becomes more complex when different materials are combined that each have specific qualities. An example put forward is
the composition of both technical and social systems, which characterize the design of technology-enhanced learning activities. In the design of such systems the great challenge “is to design the social components together with the technical components as a systematic whole” (ibid, p. 3).

Tackling such a challenge from only one of the three perspectives mentioned would most likely yield unsatisfactory results. Through the combination of the perspectives, however, each of the perspectives may play a complementary role in the shaping of digital artefacts and technology-enhanced practices, ensuring to higher extent that both the social and the technological components are accounted for. From a computer science perspective an understanding of the technological material (software and hardware) is offered. This understanding entails the affordances and restrictions of the material, i.e. answers to what is possible to technologically design, and further, the know-how to design it. The education and didactics perspective on the other hand, offer answers to why the design is done, i.e. the pedagogical goals, and how learning activities should be didactically planned for in order to meet the pedagogical goals. Thus, the education and didactics perspective combined with that of computer science, in a sense, produces design visions of technologically possible and pedagogically meaningful technology-enhanced learning practices. Finally interaction design, focusing on the end-users, provides a set of techniques for contextualizing the design innovation in terms of taking account for users needs, current practices, and usability. As such, the interaction design perspective may inform the design through aligning (i.e. operationalizing) the vision derived from computer science and education and didactics with the realities of the educational systems – thus bridging the distance from research to practice.

We started this paper by addressing that a grand challenge for educational research aimed at understanding and developing the uptake and use of Technology Enhanced Learning (TEL) is to remove its weak link to practice, and the obstacles for practice to build on research. Making a strong link between research and practice so far seems to have been a slow process might be answered with on the one hand the hunt for knowledge to further inform the research community and on the other hand the willingness to influence and collaborate with different kind of educational practices? In this paper we have through a multi-disciplinary DBR approach tried to show one way to overcome this potential dilemma, through the realization that TEL researchers need to represent different core fields but work together to actively to cumulatively build understandings (Mor and Winters, 2007). Our intention is to use the discursive approach to build common ground between ED, CS, and ID for TEL. This leaves us with the final four questions that start building the bridge between research, practice, and the domains of ED, CS, and ID and seeds the workshop.

- How can the content, techniques, tools and materials structure the design process to support the design of TEL?
- How can we integrate educational theory, computer science and ID-theory in order to gain deeper understanding of designing for today's TEL-classrooms?
- How can we evaluate interactive systems against a background current educational practice and use?
- How can sustainable TEL-activities be designed and implemented?
References


