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A survey on pervasive education

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ABSTRACT

Researchers and developers worldwide have put their efforts into the design, development and use of information and communication technology to support teaching and learning. This research is driven by pedagogical as well as technological disciplines. The most challenging ideas are currently found in the application of mobile, ubiquitous, pervasive, contextualized and seamless technologies for education, which we shall refer to as pervasive education. This article provides a comprehensive overview of the existing work in this field and categorizes it with respect to educational settings. Using this approach, best practice solutions for certain educational settings and open questions for pervasive education are highlighted in order to inspire interested developers and educators. The work is assigned to different fields, identified by the main pervasive technologies used and the educational settings. Based on these assignments we identify areas within pervasive education that are currently disregarded or deemed challenging so that further research and development in these fields are stimulated in a trans-disciplinary approach.

1. Introduction

Mobile information and communication technologies have become commonplace in recent years. The evolution of smartphones in particular has allowed users to utilize applications whenever and wherever they want. This has had a huge impact on the way people communicate with each other and their environment, and how they use and exchange information. In addition, adaption to individuals, places and situations can now be realized and different scenarios are seamlessly converging [1]. Technological progress in the form of cheap sensors and new communication technologies like sensor networks and the internet have led to an increase in the quality of services in a variety of areas including agriculture, transportation, medicine and logistics. Multimedia, mobility and cloud-based services converge to pervasive media.

In education technological developments have had a strong impact on the behavior of learners and teachers as well as on learning and teaching scenarios. For instance, the availability of digital content and a constant internet connection have led to a reduction in the relevance of traditional textbooks and the emergence of new kinds of cooperation such as in worldwide communities of practice. Additional examples will be presented in the survey below. As organizational issues are increasingly taken into account, this article considers the perspectives of learners, teachers and educational organizations in the term education. Therefore, the targeted use of pervasive media in education can be described as pervasive education. For instance, the Horizon Report claims that mobile applications, augmented reality and gesture-based interaction will be

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an extremely promising prospect in terms of e-learning over the next few years [2]. Other studies conclude that mobile technologies are both essential and challenging for e-learning, in terms of access to learning, context-specific learning and cross-contextual learning [3,4]. These technologies allow new opportunities for learning and teaching to be generated beyond the borders of the classroom [5]. The classroom of the future will be a distributed instance that combines on-site with virtual elements. This includes several services (information, communication, collaboration, etc.), which are orchestrated in a user- and context-dependent way and are based on pedagogical models and methodology [6]. The design and development of such educational arrangements not only require input from the field of computer science, but contributions from non-technical disciplines as well.

It is not uncommon for the cooperation between pedagogies, psychology, social sciences, etc. on one hand and technology and information sciences on the other to be still somewhat dysfunctional. The reasons for this are manifold: each discipline's vocabulary and methodology is different, as are their underlying cultural characteristics. Images of isolated learners in front of their PC, rigid machines restricting the student's (and the teacher's) creativity and overly complexity of computer systems that regularly fail remain ever-present. This may be the result of early technophobia in the literature and society and concerns should be carefully considered and sensitively handled. However, the huge potential of today's technologies has to be made accessible to education. Technology enhanced teaching and learning requires further development simply *because of* the high importance of education to us all.

Everyday use of computers has led to changes in our behavior and perception, often resulting in an increased reliance on technology. Consider how often you use a navigation system during a road trip (while losing orientation in unfamiliar areas), how often you contact friends and colleagues using your mobile phone (without knowing a single number) or how often you consult the Web for information (and how lost you would be without an Internet connection). A common pattern that emerges from these examples is that we are often ill prepared for upcoming situations and rely on technology to help us cope. This may lead to a reduction in practical skills. Facts may seem easy to acquire but the key to success are skills like the ability to evaluate the quality of information, to use the acquired information and to control the knowledge acquisition. For this reason, the focus of education in general, and e-learning in particular should extend from pure factual knowledge acquisition to encompass relevant practical skills. In other words: to focus on a competence-based approach.

This does not only affect content delivery but also monitoring and assessment. While factual knowledge can be easily tested in quizzes, practical skills need to be tested with respect to specific activities, e.g. by measuring the effects of a learner's activity within their environment. Since the learning process is highly individual, pervasive sensing in educational scenarios has to focus on the current user (or learner respectively) and should take into account learning goals and previous knowledge, while the surrounding physical environment can be reduced to a necessary minimum. This makes education a very attractive area for the application of pervasive computing. In addition, the spectrum of typical activities is limited and hence complex behavioral models are not required (e.g. in contrast to elaborated surveillance or emergency management scenarios).

The benefit of pervasive computing technology for education lies in its ability to overcome the limitations of traditional blended learning, i.e. to no longer sequentially restrict the learners to pre-defined times, locations, interaction and tools. Instead, pervasive education aims to seamlessly connect real-life with virtual artifacts and activities [7], tightly interweaving the paradigms (and tools) of face-to-face and online teaching and learning, in both formal and informal forms. As a result, the targeted combination of different learning activities should lead to a more intense and relevant experience. Education can now be embedded into authentic settings [8]. Artifacts, activities and cognitive processes can be contextualized in order to foster effective knowledge acquisition, individual internalization and the long-lasting applicability of knowledge and skills [9,10].

These technological opportunities remain untapped unless an adaptation of pedagogical concepts takes place. An increasingly prominent example of these new concepts is pervasive educational gaming. Here, activities in the real world are tightly coupled with effects in the digital world and vice versa [11]. This helps to raise the educational capability of e-learning applications from the simple acquisition of factual knowledge to developing complex practical skills (according to Bloom's taxonomy [12]). The aim is to create a more engaging, effective and sustainable educational offering in comparison to traditional arrangements.

This article provides a qualitative overview of the existing research and development in the emerging field of pervasive education. Beyond the existing overviews in this area [13], which take into account only a subset of pervasive learning, the available solutions are analyzed and categorized according to relevant criteria both from a technical as well as an educational perspective. Our overall objective is to explain and relate various different terms used in pervasive education and to present the existing exemplary work in order to inspire interested developers and educators. On a qualitative basis, we will identify fields within pervasive education that are of importance for future research. Furthermore, areas currently disregarded or deemed challenging are highlighted in order to stimulate further research in this area — not only by individual researchers and teachers, but also by institutions and sponsors.

The article is organized as follows: Section 2 provides the theoretical background to the field and considers the disciplines involved. Section 3 presents a comprehensive survey of examples in the field of pervasive education. These examples are categorized according to different scenarios and technologies used in the scenarios. The article concludes with findings resulting from this qualitative grouping of examples and provides an indication on the direction future research in this area is likely to take.