Computers & Education 76 (2014) 13–29

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Iterative augmentation of a medical training simulator: Effects of affective metacognitive scaffolding

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ARTICLE INFO

Article history:
Received 21 November 2013
Received in revised form
2 February 2014
Accepted 4 March 2014
Available online 18 March 2014

Keywords:
Adult learning
Evaluation of CAL systems
Simulations
Teaching/learning strategies
Metacognition

ABSTRACT

Experiential training simulators are gaining increasing popularity for job-related training due to their potential to engage and motivate adult learners. They are designed to provide learning experiences that are directly connected to users' work environments and support self-regulated learning. Nevertheless, learners often fail to transfer the knowledge gained in the simulated environment to real-world contexts. The EU-funded ImREAL project aimed to bridge that gap by developing a suite of intelligent services designed to enhance existing training simulators. This paper presents work that was a subset of this research project, reporting the iterative development and evaluation of a scaffolding service, which was integrated into a simulator for training medical students to perform diagnostic interviews. The study comprises three evaluation phases, comparing the pure simulator to a first version with metacognitive scaffolding and then to a final version with affective metacognitive scaffolding and enriched user modelling. The scaffolding service provides the learner with metacognitive prompts; affective elements are realized by an integrated affect reporting tool and affective prompts. Using a mixed-method approach by analysing questionnaires ($N = 106$) and log-data ($N = 426$), the effects of the services were investigated with respect to real-world relevance, self-regulated learning support, learning experience, and integration. Despite some limitations, the outcomes of this study demonstrate the usefulness of affective metacognitive scaffolding in the context of experiential training simulators; significant post-simulation increases in perceived relevance of the simulator, reflective note-taking, overall motivation, and feeling of success could be identified. Perceived usability and flow of the simulation increased, whereas overall workload and frustration decreased. However, low response rates to specific functions of the simulation point to a need to further investigate how to raise users' awareness and understanding of the provided tools, to encourage interaction with the services, and to better convey the benefits of using them. Thus, future challenges concern not so much technological developments for personalizing learning experiences, but rather new ways to change user attitudes towards an open approach to learning systems that enables them to benefit from all offered features.

1. Introduction

In today's knowledge society self-regulated learning, job-related training, and life-long learning are gaining increasing importance. The demands of 21st century education require learners to take responsibility for planning, monitoring, and regulating their learning. Since

Abbreviations: (A)MSS, (affective) metacognitive scaffolding service; BL, baseline; ETU, EmpowerTheUser; SAM, smiley affect measurement technology; SRL, self-regulated learning; U-Sem, user modelling infrastructure for the social web; UT, User Trial.

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http://dx.doi.org/10.1016/j.compedu.2014.03.004
0360-1315/

formal classroom settings and human instructors are in many cases overly cost- and time-intensive, there is also a shift from traditional to technology-enhanced learning (TEL) environments (e.g. Mayes, Morrison, Mellar, Bullen, & Oliver, 2009; Rogers, 2000). TEL requires new skills (e.g. critical thinking, flexibility, communication, or information and ICT literacy) but also offers opportunities to the learner, such as personalization of the learning environment and material, independence of time and place, or self-regulation of learning content, timing, and goal-setting (e.g. Narciss, Proske, & Koerndle, 2007). Learners' previous knowledge, experiences, and interests can be accounted for and situations that are closely related to job practice can be designed. There is already a wide variety of adaptive learning systems available, which automatically tailor to learners' needs and provide highly motivating learning experiences (Brusilovsky & Peylo, 2003; De Bra et al., 2013). Experiential training simulators, as one kind of TEL application, are gaining increasing popularity and importance for adult training because of their high potential to engage and motivate learners by creating realistic contexts for practicing job-relevant skills (Swartout, 2010; Thalheimer, 2009). A simulation providing an appropriate environment for learning will enhance knowledge transfer and future retrieval of skills in real-world settings. Simulations have a high motivational potential and may induce flow, i.e. a positively perceived experience and state of immersion in an activity (Csikszentmihalyi, 1990). In this sense, experiential training simulators are designed to meet the challenges of adult learning, which is often characterized as self-directed, experience-based, goal-oriented, intrinsically motivated, and relevancy-driven (Knowles, 1984). Simulations enable learners to acquire, apply and practice their knowledge and skills in safe and realistic contexts, which is particularly important in healthcare and medical education (e.g. Bloice, Simonic, & Holzinger, 2013; Chakravarthy et al., 2011; Galloway, 2009; Holzinger, Kickmeier-Rust, Wassertheurer, & Hessinger, 2009).

The EU-funded ImREAL[1] project carried out research and development in the field of experiential virtual training. The project started from the assumption that with existing training simulators there is often still a gap between the simulated environments and the real-world experiences (Dimitrova, 2013; Hetzner & Pannese, 2011). Simulations cannot perfectly replicate real-world situations and necessarily only represent a part of reality (e.g. Baeyer & Sommer, 2000; Bishop, 2003; Pontonnier, Dumont, Samani, Madeleine, & Badawi, 2013). Consequently, learners may fail in transferring the newly acquired skills from the simulation to their job, thus resulting in a so-called knowing-doing gap (Galarneau, 2005; Pfeffer & Sutton, 2000). ImREAL investigated ways to bridge the gap between simulated and real-world tasks by developing a suite of intelligent services to effectively align learning experiences made in the simulated environment with the real-world job practice, where the acquired skills are to be deployed. The target domain was interpersonal communication and the key pedagogical concepts for the ImREAL framework were adult learning (Knowles, 1984) and self-regulated learning (SRL) (Zimmerman, 2002), referring to learning processes under the responsibility and control of adult learners. Taking into account andragogic principles and adapting the cyclic SRL model of Zimmerman (2002), a framework for adult SRL was defined by linking simulated and real-world experiences. The model extends the three phases of forethought, performance, and self-reflection to integrate experiences made in the virtual and in the real world, and to incorporate peer experiences (Hetzner, Steiner, Dimitrova, Brna, & Conlan, 2011). Within the project, a pragmatic approach was pursued by augmenting existing experiential training simulators with the developed services. Research and development on simulator augmentation covered three strands, namely real-world activity modelling, enriched user modelling, and affective metacognitive scaffolding.

This paper focuses on the affective metacognitive scaffolding service aiming at enhancing SRL skills and metacognition. This service provides tailored support during the learning process (i.e. scaffolding) by prompting reflection on learning and thus, stimulating SRL activities in the performance phase and fostering metacognition in terms of regulation of cognition. We report on the service integration into a medical interview training simulator, show how the simulator and augmentation have grown and become more mature over several development phases, and present a comprehensive study covering three empirical evaluations at different stages of this maturation process. Whereas in previous papers we focused on individual evaluations conducted during and right after the training in the simulator (Berthold et al., 2012; Wesiak et al., 2013), the present work gives a long-term perspective on the successive maturation of the service and simulator extension, and also reports some tentative results obtained after real-world experiences. The next two sections give a short overview on related work from the fields of SRL (Section 1.1) and scaffolding in TEL (Section 1.2). This is followed by a description of the experiential training simulator, the EmpowerTheUser (ETU) simulator, which was augmented by the ImREAL services (Section 2). Section 3 outlines the research questions and Section 4 gives a detailed explanation of the method of our study. The results derived from the three evaluations of our study are reported in Section 5, an overall discussion and outlook to future research (Section 6) concludes this paper.

1.1. Self-regulated learning (SRL)

SRL refers to cognitive, metacognitive, and affective/motivational processes that are regulated by the learner throughout a learning experience. The learner's behaviour is goal-oriented and the applied SRL strategies describe the ways in which individuals control and direct their learning (Pintrich, 1999; Sitzmann & Ely, 2011; Zimmerman, 2002). Core processes of SRL comprise planning, knowledge acquisition, monitoring and regulation, strategy development, reflection, as well as motivational processes and motivational beliefs (Azevedo, 2005; Zimmerman, 2002). SRL itself is usually described as a cyclic process (e.g. Puustinen & Pulkkinen, 2001). Zimmerman (2002), for example, models self-regulation as a cycle made up of three phases, namely forethought (with task-analysis and self-motivational beliefs), performance (with self-control and self-observation), and self-reflection (with self-judgement and self-reaction).

A high quality and quantity of self-regulatory and metacognitive processes go hand in hand with better learning performance (at least in the long run) and achievements (Schraw & Dennison, 1994; Zimmerman, 2002). Based on a meta-analysis of 369 research reports (with 430 independent samples) of SRL in work-related training and adult education, Sitzmann and Ely (2011) suggest a framework that comprises nine fundamental self-regulation constructs as predictors for learning. Included are goal level and self-efficacy as strongest predictors, but also metacognitive strategies (with planning and monitoring), attention, time management, environmental structuring, motivation, effort, and attributions. The acquisition and use of SRL strategies can influence performance, if the strategies are applied more frequently also in subsequent learning sessions and independent practice (Bannert & Reimann, 2012; Zumbrunn, Tadlock, & Roberts, 2011). On a short-term basis, SRL-strategies are related to aspects of learning experience but not necessarily to measurable increases in performance.

[1] http://www.imreal-project.eu/.