Computers in Human Behavior 48 (2015) 654–662

Contents lists available at ScienceDirect

Computers in Human Behavior

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

A problem shared is learning doubled: Deliberative processing in dyads improves learning in complex dynamic decision-making tasks

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ARTICLE INFO

Article history:
Available online 6 March 2015

Keywords:
Simulations
Hypothesis testing
Adult learning
Learning environment
Learner dyads

ABSTRACT

Whilst micro-worlds or simulations have increasingly been used in higher education settings, students do not always benefit as expected from these learning opportunities. By using an experimental-control group design we tested the effectiveness of structuring the task environment so as to encourage learners to approach simulations more systematically. Seventy-one professionals who participated in a post-graduate-level management program worked on a management simulation either individually ($n = 35$) or in dyads ($n = 36$) while exploring the simulation (exploration phase). Peer interactions in the shared learning condition were structured so that learners were encouraged to employ hypothesis testing strategies. All participants then completed the simulation again individually so as to demonstrate what they had learned (performance phase). Baseline measures of cognitive ability and personality were also collected. Learners who explored the simulation in the shared learning condition outperformed their counterparts who explored the simulation individually. A simple manipulation of the way learners interacted with the simulation facilitated learning. Improved deliberation is discussed as a potential cause of this effect, preliminary evidence is provided. This study lends further evidence that the effectiveness of learning using simulations is co-determined by characteristics of the learning environment.

1. Introduction

Micro-world simulations have been utilised to date in various higher education settings, for example in medical and nursing education (Karakus, Duran, Yavuz, Altintop, & Caliskan, 2014; McGaghie, Issenberg, Petrusa, & Scalese, 2006; Ravert, 2002), business and management education (Lainema & Nurmi, 2006; Pasin & Giroux, 2011; Beckmann, Wood, Minbashian, & Tabernero, 2012; Romme, 2003; Zantow & Knowlton, 2005), engineering (Chung, Harmon, & Baker, 2001; Fang, Tan, Thwin, Tan, & Koh, 2011; Mendonca, Chang, Hu, & Gu, 2012), and more recently in social work education (Wastell, Peckover, White, Broadhurst, Hall, & Pithouse, 2011). The purpose of using simulations in teaching and learning varies with regard to the learning objectives, ranging from the acquisition of domain specific skills (e.g., flight simulators) to the acquisition of domain general skills of systematic enquiry, such as hypothesis testing. However, perhaps surprisingly, students often underperform in these learning environments and as a consequence, do not always benefit as expected from the use of simulations in their learning (e.g., Grössler, 2004). Potential causes for this phenomenon can be conceptualized in terms of three dimensions: the learner, the simulation, and the situation. Individual differences in learners' prior knowledge, levels of expertise, motivation, and reasoning ability and their relationships to learning outcomes have primarily been the focus of psychological research. Features of the simulated micro-worlds such as delays, feedback loops, and non-linearities are heavily featured in research in system dynamics; whilst attributes of the learning environment (e.g., how information is presented) are primarily addressed in research with an instructional design focus. In our study we explore how prescribing the way individuals interact with a simulation affects learning behaviour and subsequent learning outcomes.

1.1. Micro-worlds as learning tools

Micro-worlds are task environments attempting to simulate (more or less) comprehensively real-world problems and their underlying principles. Typically these are complex, open-ended problems that require learners to make decisions, monitor the outcomes of their decisions, and learn from feedback. As an example,

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http://dx.doi.org/10.1016/j.chb.2015.01.052
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the Furniture Factory Simulation (Goodman & Wood, 2004) is a computer-based environment that simulates the motivational processes at play in managing a group of employees over several simulated weeks of business activity. The learning objective is to gain an understanding of the interplay between managerial decisions and various motivational responses by virtual employees. It is expected that the decisions learners make when working on simulation tasks are the types of decisions professionals would make on the job.

Simulations vary widely in their domain and task characteristics. Regardless of these differences, researchers typically purport several benefits of using simulations in training and education (e.g., Wood, Beckmann, & Birney, 2009). Amongst those are: (1) Simulations represent a safe learning environment in which the impact of decisions is modelled, but obviously not realized. This provides the opportunity to experiment with different decision strategies in a risk free environment where there are no costs associated with potentially poor decision-making. (2) The use of simulations is expected to be engaging and motivating, because simulations promise a meaningful approximation to authentic problem solving (e.g., Chang, Peng, & Chao, 2010). (3) Simulations are expected to enable learners to link theory and practice. Learning with simulations seems to promise an experiential contextualisation of 'textbook knowledge'. (4) The use of simulations is thought to foster self-directed learning. Learning is self-directed in situations where the learner (rather than a tutor) is in control of the learning experience (Gureckis & Markan, 2012). For example, a student that actively searches for information that is not readily available engages in self-directed learning. When students work on simulations they, to some extent, determine which information they are exposed to depending on the decisions they make. In this regard, simulations also represent a snapshot of the real world where employees are often expected to continue learning on the job with minimal guidance. (5) Simulations are also believed to help students to practice important cognitive and meta-cognitive skills that are involved in successful problem-solving, such as systematic hypothesis testing and exploration (Beckmann & Goode, 2014; Burns & Vollmeyer, 2002). In sum, the use of simulations in higher education contexts is expected to engage and motivate students, to encourage students to contextualise their knowledge, and to practice problem-solving skills that are applicable across a wide range of contexts.

In contrast to the many suggested benefits of using simulations in learning, the evidence as to whether students actually learn effectively when working on these tasks is mixed (Bell, Kanar, & Kozlowski, 2008; Gosen & Washbush, 2004; for an early review see Lane, 1995). Some studies have found simulations to provide effective learning environments (Chung et al., 2001; Ravert, 2002), others were unable to replicate such findings (Gresse van Wangeheim et al., 2009; Njoo & de Jong, 1993; Qudrat-Ullah & Karakul, 2007; Stouten, Heene, Gellynck, & Polet, 2012, see also the discussion on poor performance of participants in problem-based learning environments in general, Ellis, Marcus, & Taylor, 2005). Grössler (2004) identified no less than 15 issues concerning the use of simulations as teaching and research tools, including research design and methodological obstacles to evaluating the effectiveness of simulations as learning tools, task difficulty due to complexity, and, depending on individual differences in cognitive ability and knowledge, difficulties students often have in making sense of the task. The latter can lead to random decision-making, which impedes any learning.

It is clear that an evaluation of the evidence for or against the effectiveness of simulations as learning tools needs to reflect on various challenges. These challenges include methodological constraints as well as conceptual shortcomings. With regard to the former, one major issue is that quite a few studies that report positive effects on learning do not employ study designs that would allow such conclusions. Many studies, for instance, lack a control group (e.g., Adobor & Daneshfar, 2006; Chung et al., 2001; Cronan, Douglas, Alnuaimi, & Schmidt, 2011; Hung, 2008; Qudrat-Ullah, 2010), which challenges the validity of claims that reported performance increases can in fact be attributed to the use of the particular simulation. Another challenge is ambiguity in what constitutes an indicator of learning success. Studies variously report on self-perception of learning, knowledge tests, causal diagrams, various performance indicators within the simulation, and performance in transfer problems or so-called real-life outcomes.

Student motivation, and as a consequence student engagement, are often reported to be high when simulations are employed (e.g., Chang et al., 2010; Shellman & Turan, 2006). However, this does not necessarily translate into better learning (Adobor & Daneshfar, 2006; Stouten et al., 2012). For instance, Stouten et al. report that whilst learners had confidence in the simulation, found it a valid model of reality, and believed that they had learned important content, no learning was observed with regard to objective learning outcomes (e.g., changes in participants' knowledge). Indeed, students often perform relatively poorly in simulations (Paich & Sterman, 1993). Also performance indicators derived from within the simulation are not necessarily a valid indicator of learning success. "Game performance" scores often reflect success in pursuing some sort of optimisation goal (e.g., maximising market share or minimising staff costs). Achieving good performance scores requires decision-making behaviour which is different from exploration behaviour geared towards the acquisition of structural or functional knowledge about the relatedness of decision variables and outcome variables in a simulation. In other words, the operationalization of game performance tends to reward a different kind of behaviour than what these scores are supposed to be indicative of (i.e., learning behaviour).

Transfer scores (i.e., performance success outside the simulation itself) can be seen as indirect learning indicators at best because success in learning within a simulation does not always translate into success in other tasks or 'real-world' complex, dynamic problems. Beckmann and Goode (2014) have proposed that such lack of transfer might be caused by one of the core features of simulations, namely their attempt to provide a contextualised learning environment by using semantically meaningful variable labels and cover stories. It can be argued that the emphasis on contextualisation of learning with simulations comes with the risk that learning outcomes (i.e., knowledge and understanding) achieved in more or less narrowly defined contexts are less likely to be utilised in novel, albeit homomorphous real-life situations (Beckmann & Goode).

Various reasons are discussed for the limited effectiveness of simulations as learning tools. One potential reason for the 'under-performance' of students in simulations is that students are cognitively overwhelmed by the complexity of the task (Gonzalez, 2005; Gonzalez, Vanyukov, & Martin, 2005; Wood et al., 2009). Several studies have tried to address this issue (e.g., Lerch & Harter, 2001). Parush, Hamm, and Shtub (2002) provided learners with a 'learning history tool' which allowed access to and tracking of their past decisions and subsequent effects. Externalisation of the decision history was discussed as one way to reduce cognitive demands of the task which led to better performance compared to a control group who played the simulation in the traditional way.

Another factor that contributes to an under-utilisation of learning opportunities in simulations is the tendency of learners' to inadequately encode the complexity of the task by focussing on surface features of the simulation and by producing high decision-making densities, i.e., acting too quickly and therefore unreflectively. Such passive encoding of simple action-outcome