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Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation

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ABSTRACT

Although the proponents of game-based learning argue that educational games engage students and afford better learning outcomes, the impact of educational games on motivation and learning performance is still unclear. Research suggested that the addition of scaffolds in computer-supported environments may improve students' learning. Therefore, this study examined the effects of scaffolding on secondary students' individual and collaborative game-based learning. A total of 254 secondary school students from eight different classes participated in the study and they were randomly assigned to four conditions: (a) individual-control (IC), (b) individual-scaffold (IS), (c) collaborative-control (CC), and (d) collaborative-scaffold (CS). The results of the structural equation modeling revealed that scaffolding had an impact on students' motivation and learning performance. In addition, hard scaffolding moderated the relationship between soft scaffolding and students' learning performance. The results provided empirical supports for the use of collaborative game-based learning environments. However, in order to maximize the effects of collaborative game-based learning, hard scaffolds should also be introduced to guide students' learning experience. This study offers directions in designing scaffolding in game-based learning environments.

1. Introduction

Proponents of game-based learning (GBL) suggest that educational games induce a positive experience that may be harnessed for learning (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). GBL may encourage students to acquire knowledge and offer a rich context that allows students to reinforce and consolidate their knowledge through practice. GBL is rooted in the idea that virtual environments look motivational because we can quickly see and understand the connections between the learning experience and our real-life work (Prensky, 2001). In the context of GBL, students usually pursue solutions to open-ended problems by synthesizing, analyzing, and evaluating multiple modes of information and using critical thinking skills to form strategies and solve problems. GBL offers students the opportunity to control learning processes, accumulate subject matter knowledge, and apply generic skills such as self-regulation and self-management. As a result, the inherent openness of GBL environments introduces more cognitively complex tasks in the learning process, and students need to perform metacognitive control to effectively undertake GBL (Wouters & van Oostendorp, 2013). Although the strength of GBL seems to lie in giving students opportunities and motivating them to work in a personal and meaningful way toward a "goal", several researchers observe students' deficiencies in acquiring detailed concepts of the domain and attitudinal learning effects (Clark et al., 2011; Habgood & Ainsworth, 2011; van Eck, 2006). For example, novice students often exhibit an absence of prior knowledge, whereas inexperienced and young problem solvers lack essential metacognitive skills for engaging in GBL (Lee & Chen, 2009; Parasleva, Mysirlaki, & Papagianni, 2010). Researchers have examined the utility of scaffolding that guides students to overcome this challenge (Barzilai & Blau, 2014). While the provision of scaffoldings tends to facilitate technology-enhanced learning, its effects on GBL have appeared to be inconsistent and somewhat negative depending on the conditions of use (Huizenga, Admiraal, Akkerman, & Dam, 2009; Wouters & van Oostendorp, 2013). Moreover, there is a dearth of research examining how different scaffolds influence GBL (e.g. Barzilai & Blau, 2014; Lee & Chen, 2009). In this study, we investigated two types of scaffolds in

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GBL: hard scaffolds (static scaffolds that are usually provided by computers) and soft scaffolds (dynamic scaffolds that can be provided by peers during collaboration) (Ge & Land, 2004; Saye & Brush, 2002). Particularly, we examined whether hard or soft scaffolds or the combination of scaffolds would better promote students' learning and motivation in GBL. Further examination of different scaffolds in the context of GBL would shed light on the effectiveness and efficiency of knowledge acquisition and motivation in the GBL environments.

2. Theoretical background

2.1. Scaffoldings

Wood, Bruner, and Ross (1976) introduced the term scaffolding as tutoring or assistance provided in the learning processes to assist students with attaining levels of understanding impossible for them to achieve without assistance. Saye and Brush (2002) conclude that there are two types of scaffoldings to guide students to solve ill-structured problems: (a) hard scaffolds and (b) soft scaffolds. *Hard scaffolds*, also called fixed scaffolds, are static and are not adaptable to meet individual students' learning needs. Recent research on hard scaffolds with technology-based learning environments has yielded mixed results. Some studies have produced positive results, whereas other studies indicated that hard scaffolds do not enhance students' learning within such environments (e.g., Demetriadis, Papadopoulos, Stamelos, & Fischer, 2008; Ge, Chen, & Davis, 2005; King, 1992; Papadopoulos, Demetriadis, Stamelos, & Tsoukalas, 2009; Vreman-de Olde & de Jong, 2006).

Some researchers argue that hard scaffolds are not always effective because they are not adaptable (Bulu & Pedersen, 2010; Chen, Wu, & Jen, 2013; Ge & Land, 2004). As a result, hard scaffolds may not address students' learning needs nor support students' regulatory behaviors in technology-enhanced learning environments. *Soft scaffolds*, on the other hand, can provide spontaneous and timely support that better facilitates students' learning processes (e.g. Azevedo, Cromley, & Seibert, 2004). Ge and Land (2004) argue that student–student interaction during collaboration can be a form of soft scaffolds, which mitigates the shortcomings of hard scaffolds. In this research, we defined soft scaffolds as collaboration among students during learning processes. Next, we summarize and synthesize findings from a line of research investigating the potentials of hard and soft scaffolds for supporting student's GBL.

2.2. Hard scaffolds in GBL

Hard scaffolds are frequently used in the technology-enhanced learning environments where the presence of teachers is often absent. Question prompts appear to be the most common application of hard scaffolds. They are fixed and pre-scripted to facilitate learning processes and make the connections between knowns and unknowns. Researchers have shown positive effects of question prompts on students' knowledge acquisition and ill-structured problem-solving skills in computer-supported learning environments (e.g., Chen, 2010; Ge & Land, 2003; Ge et al., 2005). Question prompts can guide students through the process of problem representation and solution generation by engaging students in activities including self-explanation, self-questioning, self-monitoring, and self-reflection (King, 1991, 1992; Lin & Lehman, 1999). Specifically, King and Rosenshine (1993) found that question prompts can elicit explanations from students, activate their prior knowledge, and engage them in high-level elaboration. Moreover, Lin (2001) claimed that question prompts may help students focus their attention on contradictory ideas and construct new understanding without direct teaching of specific strategies. Across various domains, the use of question prompts have been found to be an effective cognitive strategy in helping students represent and solve problems. For example, in studies on writing tasks, question prompts were found to help students recognizing problems at the planning level and promoting reflective writing skills (Chen, Chung, & Wu, 2013; Papadopoulos, Demetriadis, Stamelos, & Tsoukalas, 2011; Scardamalia, Bereiter, & Steinbach, 1984). In the domain of information technology, Ge and Land (2003) found question prompts helped students representing problems, constructing arguments, developing solutions, and self-monitoring and evaluating their problem-solving process.

In recent years, researchers have started exploring the implementation of scaffolds to support students' GBL and the role of scaffolds in GBL affect students' learning outcomes and motivation. The integration of embedded scaffolds can build the connection between game content and disciplinary content (Charsky & Mims, 2008; Neulight, Kafai, Kao, Foley, & Galas, 2007). Reiser (2004) proposed that scaffolds may provide support for the tasks that attract students' attention to critical ideas and connections that might be otherwise overlooked. The use of question prompts is a prominent approach to foster GBL. Leutner (1993) observed that students are more likely to acquire domain-specific knowledge in GBL than those without the provision of question prompts. Further, Lee and Chen (2009) demonstrated that providing students with question prompts helps them focusing on the effective and correct ways to problem solving in GBL. Hwang, Wu, and Chen (2012) suggested that the games embedded with question prompts can promote flow experience, learning attitudes, interest, and technology acceptance and improve students' learning achievements. A recent meta-analysis study also showed that students provided with question prompts could better focus their attention and improve learning (Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013).

While question prompts are used in GBL to enhance and foster domain-specific knowledge, adding external scaffolds to games should take into consideration individual needs and knowledge. Simply providing students with question prompts to facilitate GBL may not be sufficient because students may not be able to mentally integrate the abstract world of the games that is relevant to the knowledge (Clark et al., 2011; Habgood & Ainsworth, 2011). Barzilai and Blau (2014) also found that combining question prompts before or after the game play may reduce students' perceived learning, which, in turn, impedes their understanding of the disciplinary knowledge. The effects of question prompts on GBL are mixed throughout the literature and the knowledge of how hard scaffolds and soft scaffolds work together in GBL remains unclear. Therefore, we need a better understanding of the cognitive and affective effects of hard and soft scaffolds in GBL in order to successfully delineate types of scaffolds that may promote learning while maintaining motivation.

2.3. Soft scaffolds in GBL

Embedding soft scaffolds by providing collaboration opportunities can be viewed as a valuable resource. Collaboration allows students to provide and receive explanations, co-construct ideas, resolve conflicts, and negotiate meaning (Brown & Palinscar, 1989; Johnson, Johnson, Stanne, & Garibaldi, 1990; Slavin, 1996). Research evidences that collaboration promotes the development of cognitive structures as individual reconcile differences between their own ideas and the ideas of others, ask questions, and explain their reasoning in finding solutions (O'Donnell and King, 1999; Teasley, 1999). Working collaboratively also provides opportunities for the development of members' cognitive structures and cultivates positive attitudes toward the task and stronger task

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