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The interplay between cognitive task complexity and user interaction in mobile collaborative training

Iris Reychav [a, *], Dezhi Wu [b]

[a] Department of Industrial Engineering and Management, Ariel University, P.O.B 40700, Ariel, Israel
[b] Department of Computer Science & Information Systems, Southern Utah University, Cedar City, UT 84720-2498, USA

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A B S T R A C T

Mobile collaborative training is increasingly crucial in today's mobile world, in that much complicated collaborative professional work is being conducted in the field and globally. Nevertheless, this field is lacking in holistic empirical studies to effectively understand this important phenomenon and its challenges. Accordingly, grounded upon cognitive load theory and Bloom's taxonomy, we designed and conducted a set of mobile collaborative training field experiments with 364 participants to examine the impact of the various complexities of cognitive tasks on user performance and perceptions, using a non-interactive vs. interactive mobile training app in both individual and group settings. The study findings provide useful insights into the interplay between cognitive task complexity and user interactions with both peers and technologies in a mobile collaborative training. We found that at the lowest level of cognitive complexity, user performance and perceptions of mobile training achieved the desirable improved results between non-interactive and interactive mobile app use. At the middle level of complexity, no significant differences were found. Surprisingly, at the highest level of complexity, the results indicate that cognitive task complexity and user interactions with both peers and technology significantly decreased user performance and user perceptions of mobile training. This study also offers practical implications whereby educators and training practitioners need to clearly balance the interface design of mobile training systems and different complexity levels of cognitive tasks in various training domains, in order to to achieve the desired training outcomes.

1. Introduction

Mobile collaborative training is gaining serious attention in today's increasingly mobile world, in that many complicated projects and professional work, especially in the science, technology, engineering and mathematics (STEM) fields, are constantly conducted collaboratively in the field and globally. Lately, Kozlov and Groβe (2016) found that complicated problems faced by medical practitioners are influenced by their collaborative learning and problem solving efficiency. Further, complicated learning tasks increase cognitive load which results in reduced task performance (Van Gog, Kester, & Paas, 2011). Recent research calls are made to identify effective learning strategies to significantly reduce cognitive load in mathematical processes (Buettner, 2015), which affect learning effectiveness (Gillmor, Poggio, & Embreston, 2015). Thus, there is a need to investigate how to conduct effective collaborative training and learning, in which tasks are likely to always high in intrinsic load for all learners (Van Gog et al., 2011). Not surprisingly, current mobile training studies focusing on cognitive complexity are still scant due to its emerging nature.

A recent mobile collaborative training study has investigated the role of individual learning in groups through text and video content delivery in tablets, and found that texts work more effectively with groups, and videos are more influential for individuals (Reychav & Wu, 2015a,b). However, the field lacks an in-depth understanding on how different levels of cognitive complexity impact mobile collaborative training. Evidently, in the business world, how to effectively embrace mobile collaboration is also a myth, and empirical studies are needed to understand this important phenomenon and its challenges. Thus, we are motivated to conduct a holistic empirical study to answer a few important research questions in this area: How can cognitive task complexity and different work settings (individual vs. collaborative) interplay in a mobile

* Corresponding author.
E-mail addresses: irisre@ariel.ac.il (I. Reychav), wu@suu.edu (D. Wu).
URL: http://www.ariel.ac.il/iem/Faculty.aspx, http://www.suu.edu/faculty/wu

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collaborative training setting? How do they collectively impact user training perceptions and performance in both a non-interactive and an interactive mobile training platform? What implications can we draw on from the study to improve current mobile collaborative training?

To the best of our knowledge, up to date, non-empirical studies have addressed these research questions. Accordingly, in this study, we have taken the bold step of training users to learn a complicated subject area (i.e., mathematics) through a mobile training app (non-interactive vs. interactive), in order to understand how mobile technologies can support cognitive intensive tasks. In addition, we have incorporated a team component to make the mobile training process collaborative, so we can examine how the advanced mobile training platform can be used to accommodate various levels of cognitive task complexity and different levels of user interactions with mobile collaborative technologies.

This paper proceeds as follows. Following the introduction, we describe the theoretical background to this study, and then present the main focus of the study. Afterwards, we propose a research framework and describe our research methods. Lastly, we report data analysis results, discuss the study findings and future research directions.

2. Theoretical background

In the past decade, fostering collaborative and student-centered environment for training in complicated subjects, e.g., STEM, has been crucial, in that students can be exposed to a collaborative environment to share their ideas with their community, analyze and evaluate the ideas of their peers (National Council of Teachers of Mathematics, 2000). Staples (2007) asserts that the term collaborative “implies a joint production of ideas, where students offer their thoughts, attend and respond to each other's ideas, and generate meaning or understanding through their joint efforts” (p, 4). Prior research indicates that mathematical communication within the learning community is critical for the development of students' reasoning and mathematical understanding (Alrø & Skovsmose, 2003; Forman, 2003). By sharing and discussing their ideas with others, student mathematical reasoning can develop more readily (Lampert and Cobb, 2003). The most successful instances of collaboration occur when collaborators propose, define ideas and explain their reasoning to each other (Howe & Mercer, 2007). Indeed, the classroom is a social context for the creation and sharing of knowledge (Forman, 2003; Goos, 2004). By participating in mathematical discussions, proposing and defining conjectures, and responding to the arguments of others, students' meaningful mutual communication occurs in a community type of interactive classrooms (Forman, 2003; Goos, 2004).

In contrast to traditional lectures where students are passive recipients of information, educational technology has long been recognized as a valuable approach to improving the mathematics achievement (Chang, Yuan, Lee, Chen, & Huang, 2013; Pilli & Aksu, 2013). Recent educational studies have been focused on more and more mobile technologies, since today's learners grow up with technologies and are also given the name “digital natives.” With the pervasive use of mobile technologies, academics and practitioners have started to explore how we can take advantage of advanced mobile technologies as a training platform to engage today's learners and further develop training in complicated subjects such as mathematics (Bouta, Retalis, & Paraskeva, 2012). Although mobile training is not a new concept, the field has recently begun to explore in greater depth issues in the mobile collaborative training area. Based on 347 mobile collaborative groups in two different mobile content delivery training modes, including video and text, a recent study (Reychav & Wu, 2015a,b) found significant differences between individual and group learning modes in regards to how the mobile collaborative learning processes influences learning outcomes. Moreover, social networks also have a compound impact on the mobile collaborative knowledge acquisition processes (Reychav, Ndicu, & Wu, 2016). Cognitive absorption plays a significant role in affecting users' deep involvement, which in turn affects mobile training outcomes (Reychav & Wu, 2015a, b). Next, we introduce the theoretical foundation for our study.

2.1. Constructivism theories

- ***Cognitive constructivism***

Since the early 1900s, educational research has moved towards a constructivist philosophy. In general, constructivism regards learners as active, rather than passive participants in their learning and believes that learning is a result of the learner's construction of new knowledge based upon their previous knowledge (Huitt, 2003).

Two well-known cognitive constructivist theorists were Dewey (1900, 1938) and Bruner (1960, 1996). Dewey (1900) viewed education as a social matter, in which teachers should be mindful of the fact that children are people, in need of social interaction. The other constructivist considered is Bruner (1960, 1996). With proper structuring of curriculum, Bruner (1960) believed that students could be taught information at a much younger age than was previously thought; he believed that a seven-year-old child could be taught calculus concepts as long as the concepts were presented at the child's concrete operational level. Bruner (1996) asserted that the purpose of education was to help learners construct new meanings, and not to simply to manage information given to them.

- ***Social constructivism***

While the theories of Dewey (1900, 1938) and Bruner (1960, 1996) centered on cognitive constructivism, Vygotsky (1978) believed in constructivism by means of a social perspective. Vygotsky was best remembered for his zone of proximal development (ZPD), which he used to “explain the difference between what learners know and are able to do on their own and their potential development under adult guidance or in collaboration with more capable peers” (Stapa, 2007, p. 137). Vygotsky's work concentrated on the notion that social interaction is a prerequisite in order for higher learning to occur (Guk & Kellogg, 2007; Stapa, 2007).

Vygotsky (1978) viewed learning as a social process, and much of his work centered on the roles of dialogue, language and play in the learning process. He believed that before learning took place at an individual level, it must be experienced at a social level. Social interaction, regarded as being the center of Vygotsky (1978)'s work, was required for higher learning to occur (Guk & Kellogg, 2007).

2.2. Individual and collaborative learning

Research on learning in past decades has emphasized the important role that collaborative learning plays in the learning process. Collaboration is expected to promote activities like elaboration, justification and argumentation that trigger learning mechanisms (Fischer, Kollar, & Stwgmann, 2013). Information technologies are designed to support collaborative work, not only in the business world, but also in education. Research into online collaborative learning (Hansford & Wylie, 2002) shows that for collaborative learning to occur, students have to exhibit a high degree of involvement. Collaborative learning may provide a natural context for producing explanation for the individuals. Individual participants who engage in learning conversations are