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The Impact Of Cognitive Task Complexity on Mobile Collaborative Training

Iris Reychav
Ariel University Center, irisre@ariel.ac.il

Dezhi Wu
Southern Utah University, USA, wu@suu.edu

THE IMPACT OF COGNITIVE TASK COMPLEXITY ON MOBILE COLLABORATIVE TRAINING

Iris Reychav
Department of Management and Industrial Engineering
Ariel University, Israel
irisre@ariel.ac.il

Dezhi Wu
Department of Computer Science & Information Systems
Southern Utah University, USA
wu@suu.edu

Abstract:

Mobile collaborative training is getting increasing attention in today's mobile world. However, the field lacks solid empirical studies to understand how to effectively design mobile collaborative training systems in order to make user interactions more engaging and meaningful to mobile learners. Grounded upon cognitive load theory and Bloom's taxonomy, this paper proposes a research framework and a set of research questions to understand how cognitive task complexity interplays with user interactions on a mobile collaborative training platform, and how they collectively affect training outcomes and user perceptions about the training. Accordingly, we designed a set of mobile collaborative training field experiments, and we plan to recruit about 400 participants to work on different levels of cognitive complexity tasks while interacting with *a non-interactive* vs. *an interactive* mobile collaborative app. at *an individual* vs. *a group* work setting. The study is currently ongoing, and we expect this study will offer some useful insights to the mobile collaborative training sectors and academic institutions.

Keywords: cognitive task complexity, cognitive load theory, Bloom's taxonomy, mobile collaborative training

I. INTRODUCTION

To date, numerous complicated STEM projects and professional work are constantly conducted collaboratively in the field and globally, so mobile collaborative training is increasingly getting more attention in both business and education fields. In terms of the effectiveness of different content delivery modes, recent research (Reychav and Wu, 2015) has reported that text works more effectively with groups, and video is more impactful for individuals in a mobile collaborative training context. Further, to foster mobile collaboration, social networks play a positive role in improving training and learning effectiveness (Reychav et al., 2016). Another recent study (Kozlov & Groʒe, 2016) also reported medical practitioners faced challenges in dealing with complicated problems collaboratively due to efficiency issues with their collaborative learning and problem-solving skills. Cognitive load is increased when users figure out complicated tasks, and thus results in reduced task performance (Van Gog, Kester, & Pass, 2011).

Nevertheless, none of prior studies have investigated how different levels of cognitive task complexity in a mobile collaborative platform can be designed to effectively engage users to achieve positive training outcomes. People are seeking such insights and solutions to improve the delivery of mobile collaborative training. In the business world effective 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 an empirical study to answer this major research question.

Accordingly, in this study, we conducted a mobile collaborative training study with mobile users who tried 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 also 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 research-in-progress paper proceeds as follows: following the introduction, we present a brief theoretical background. Then we present our research questions and proposed research framework. Afterwards, we describe our study design and planned future research for this study. Lastly, study implications are discussed.

II. BRIEF THEORECTICAL BACKGROUND

In traditional lectures, students are passive recipients of information. Today's educational technology has long been recognized as a valuable approach to improve student performance. Higher education institutions and training sectors have started to experiment mobile learning and training due to the pervasiveness of mobile technologies (Bouta et al., 2012). Cognitive absorption plays a significant role in affecting users' deep involvement, which in turn affects mobile training outcomes (Reychav & Wu, 2015). Next, we briefly introduce the related theories for our study.

Constructivism Theories

- ***Cognitive Constructivism***

Since the early 1900s, educational research has moved towards a constructivist philosophy. Piaget's (1932) work built the major foundation for cognitive constructivist approaches to teaching and learning. 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). 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***

Vygotsky (1978) believed in constructivism by means of a social perspective. Vygotsky was most 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). Social interactions, regarded as the center of Vygotsky’s (1978) work, were required for higher learning to occur (Guk & Kellogg, 2007).

Cognitive Load Theory

To understand how the various levels of cognitive complexity plays a role in the mobile collaborative training, Cognitive Load Theory (CLT) (Kirschner, 2002; Paas et al., 2003) is particularly useful for this study. CLT focuses on learning from complex cognitive tasks based on what is known about human cognitive architecture (Sweller, 1988, 2004). According to CLT, learning task complexity is determined by the number of new interacting information elements to be learned; the newer the interacting elements, the more complex the task. Although highly interactive information elements may be processed in isolation, they can only be understood when all of them and their interactions are processed simultaneously in individual learning settings (Ayres & Paas, 2009). Kirschner et al. (2009 a, b, 2011) have recently emphasized an alternative way of effectively dealing with individual working memory (WM) limitations, namely making use of the multiple WMs of individuals in a collaborative learning setting. From their perspective, groups of collaborating learners are considered to be information-processing systems (Hinsz et al., 1997). Within these systems, valuable task-relevant information and knowledge held by each group member can be consciously and actively shared (i.e., retrieving and explicating information), discussed (i.e., encoding and elaborating information), and remembered (i.e., personalising and storing information) (Hinsz et al., 1997; Tindale & Kameda, 2000; Tindale & Sheffey, 2002). As long as the information is communicated between the group members and they coordinate their actions, not all group members need to possess the necessary knowledge, or process all available information alone and at the same time (Johnson et al., 1989).

Bloom Taxonomy Theory

One of the basic questions facing educators has always been “where do we begin in seeking to improve human thinking?” Bloom’s (1971) Taxonomy is a multi-tiered model of classifying thinking according to six cognitive levels of complexity. The lowest three levels are: knowledge, comprehension, and application. The highest three levels are: analysis, synthesis, and evaluation. The taxonomy is hierarchical, in that each level has also mastered the material at the “knowledge” and “comprehension” level. During the 1990s, a former student of Bloom’s, Lorin Anderson, led a new assembly which met for the purpose of updating the taxonomy. The changes that resulted from this occur in three broad categories: terminology, structure, and emphasis. In essence, Bloom’s six major categories were revised from noun to verb forms. Additionally, the lowest level of original, ‘knowledge’ was renamed to become ‘remembering’. Finally, comprehension and synthesis were retitled to understanding and creating (Anderson & Krathwojl, 2001).

The revised Bloom’s Taxonomy takes the form of two-dimensional table. One of the dimensions identifies the Knowledge Dimension (or the kind of knowledge to be learned) while the second identifies) and the other dimension called the Cognitive Process Dimension (or the process used to learn). The intersection of the knowledge and cognitive processes categories form twenty-four separate cells. The knowledge dimension is composed of four levels that are defined as Factual, Conceptual, Procedural, and Meta-Cognitive. The Cognitive Process Dimension includes six levels that are defined: Remember, Understand, Apply, Analyze, Evaluate, and Create.

Mapping Bloom’s Taxonomy’s Knowledge Dimension to Three Levels of Complexity

According to Bloom's taxonomy, the knowledge dimension consists of four general types of knowledge: factual, conceptual, procedural, and metacognitive. Factual knowledge consists of the terminology, details and elements that students must know to be acquainted with a particular subject matter. Knowing what to call something is an example of factual knowledge. Conceptual knowledge is the knowledge of classification and categories, principles and generalization, and theories, models, and structures. It is knowing the interrelationships among the basic elements within a larger structure that enables them to function together. Procedural knowledge is knowing how to make or do something. It includes methods, techniques, algorithms and skills. It also includes the criteria one uses to determine when to use appropriate procedural knowledge. Finally, metacognitive knowledge is knowledge of cognition in general as well as awareness and knowledge of one's cognition. This includes strategic knowledge, task knowledge, and self-knowledge.

In this study, we use Bloom's Taxonomy as a guideline to differentiate three different levels of cognitive task complexity which is illustrated in Figure 1.

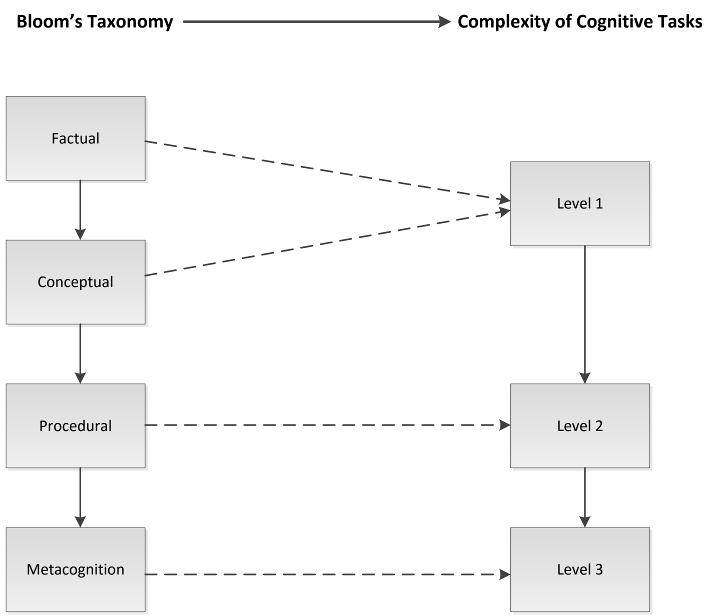

Figure 1: Mapping Bloom's Taxonomy to Three Levels of Cognitive Task Complexity

In our study, we used math materials developed by mathematical experts in education who are responsible for decision making on training and learning curriculum material in Israel. The materials were categorized by three levels of complexity. The first level reflects the Bloom's Taxonomy's factual knowledge, which includes requesting the participants to list math concepts, remember, understand, summarize, and classify pattern. This level also includes the conceptual knowledge, which refers to cognitive processes such as describing, interpreting, experimenting, explaining, assessing and planning. The second level reflects the procedural knowledge that includes the following cognitive process: tabulating, predicting, calculating, differentiating, concluding and composing. At this stage, participants were asked to formulate conclusions about the attribute of parallelogram patterns and differentiate patterns from different shape which one is considered as parallelogram. The third level reflects metacognitive knowledge, including the following cognitive processes: appropriate use, execution, construction, achievement, action and actualization. We assume that providing interactive cognitive tasks on the mobile platform in math will enable the individuals to execute the cognitive process and therefore achieve higher performance of this level of complexity.

Proposed Research Framework and Research Questions

In this study, we attempt to answer the following three main research questions through a set of field experiments.

RQ1: *What is the impact of cognitive task complexity on (1) user performance and (2) user perceptions on the basic (i.e., non-interactive) mobile training platform in both individual and collaborative settings?*

RQ2: *What is the impact of cognitive task complexity on (1) user performance and (2) user perceptions on the interactive mobile training platform in both individual and collaborative settings?*

RQ3: *What are differences on (1) user performance and (2) user perceptions between the basic (non-interactive) and interactive mobile training platforms at both individual and collaborative settings?*

To understand how different levels of cognitive task complexity and work settings impact user performance and user perceptions about mobile collaborative training in a basic mobile collaborative training app vs. an interactive mobile training app, we proposed the following research framework to guide our study. Figure 2 illustrates the research framework that highlights the main focus of this study.

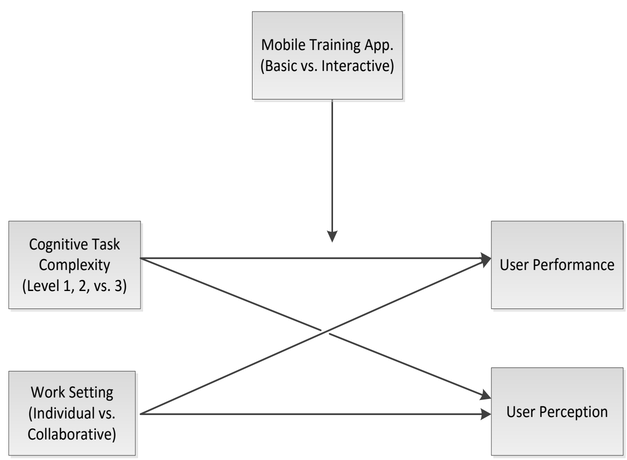

Figure 2: The Research Framework

III. RESEARCH METHOD

A set of controlled field experiments are planned to be conducted at two schools, which are considering adapting mobile tablet technologies to promote collaborative learning and training. We plan to recruit about 400 study participants, and will split them into groups in two different work settings: (1) Individual Setting: about half of the groups were asked to work individually, and they can share ideas with the remaining groups; however, the individuals were required to make individual decisions on answers to a set of cognitive training tasks, and (2) Collaborative Setting: about the other half of groups were asked to work collaboratively, in order to achieve their group-level agreements to the same set of cognitive training tasks. The following figure 3 shows two snapshots of the interactive mobile app to be used in our field experiments.

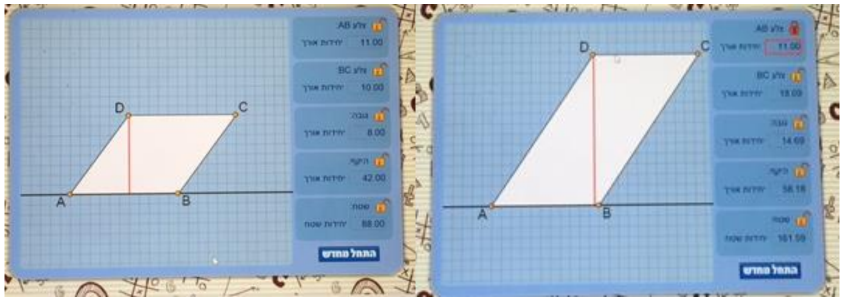

Figure 3: Cognitive Task Snapshot on the Interactive Mobile App.

(i.e., Left side indicates the initial interface and right side results after lock side manipulation)

STUDY PLAN AND IMPLICATIONS

We plan to conduct a set of field experiments to examine the proposed research model with approximately 400 students at multiple schools which have actively adopted mobile technologies for teaching and learning in their curricula. We split students into small study groups in different classes. Once the experiment is conducted, we will analyze our experimental data in different mobile collaborative training settings and further compare the results to examine whether our proposed research framework works, and how we can address our major research questions in order to offer useful insights to improve our understanding how the cognitive task complexity and mobile collaborative app design play a role in the evolving mobile collaborative training field.

In this study, we will measure both objective user performances and subjective user perceptions about field mobile training in various scenarios to answer our key research questions. The study results shall provide us with rich information to understand the cognitive task complexity to mobile training design and how to run it in different scenarios. Our proposed study clearly will contribute to the field with an in-depth understanding how cognitive task complexity plays a role in using mobile technologies to deliver training in a complicated subject domain, such as mathematics through a set of field experiments. This study is currently ongoing. By the time when the SIGED meeting will be held in Dec., we should be able to report and share our empirical findings with the SIGED participants.

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