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Toward a mathematical model of motivation, volition, and performance

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ABSTRACT

The goal of this study was to (1) empirically examine factors that affect human performance in a simulation-based learning environment, employing the framework of the integrative theory of Motivation, Volition, and Performance (MVP) (Keller, 2008a) and (2) develop and statistically evaluate a mathematical MVP model that can be applied to other digital learning environments. The development of a mathematical MVP model can provide empirical support for the elements included in the MVP theory and serve as a tool for designing effective digital learning environments. A regression analysis of motivational, volitional, and performance data of 62 graduate students that interacted with an online simulation revealed a significant model that explained approximately 70% of the variation in student satisfaction through motivational and volitional processing variables suggested by the MVP theory. Students' interest and curiosity toward the learning environment had the highest positive predicting power on students' satisfaction, while the volition processing variable had the lowest predicting power. Implications for the digital learning environments design and directions for future research are discussed.

1. Introduction

Digital learning has become an integral part of all educational systems today. The current generation of students cannot imagine learning without computer-based training, interactive simulations, online multimedia presentations, intelligent tutors, or instructional video games. The design of effective digital learning environments is becoming increasingly important for students' success, as we recognize the greater importance of providing students with effective and engaging learning. Researchers have thus explored a myriad of technological, cognitive, environmental, sociological, genetic, and motivational factors that can influence human performance in digital learning environments as well as the processes and interrelationships that occur between these factors using various theories and models. Most of the early research in this domain focused on technological innovations rather than effective design principles that facilitate learning and engagement (Mayer, 2009). However, over the last two decades that research focus has shifted from a predominantly technology-centered to a more learner-centered approach.

Many well established and comprehensive learning theories have been used as the research framework for studying digital learning environments and human performance. Examples are Zimmerman's (2001) theory on self-regulated learning, Mayer's (2001) information processing theory, and Keller's (1999) ARCS motivation theory. In addition, more specific theories have focused on particular domains of inquiry to explore the different factors that can affect human performance in digital learning environments. Keller (2008a, 2008b) proposed systematically investigating these factors using the integrative theory of Motivation, Volition, and Performance (MVP). That focus is the learning, motivational, volitional, and environmental factors that can affect human performance. This paper empirically investigates the factors that influence learner performance in a digital learning environment, employing the framework of the MVP theory to develop an initial mathematical MVP model that can be applied to other digital learning environments to diagnose motivational, volitional, and/or performance problems in these environments and better predict student performance.

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1.1. Factors that influence human performance in digital learning environments

Multiple factors can affect human performance in digital learning environments. For instance, cognitive design strategies and digital learning continue to be one of the prominent fields of research in this particular domain. Digital environmental inputs like pictures, videos, and hyperlinks can affect learner information processing, motivation, and attention (e.g., Roda, 2010). According to Mayer's (2009) meta-analysis study, lessons containing words with pictures contribute to more positive learning outcomes than lessons that contain words only. On the other hand, including multimedia may inhibit the learning of complex cognitive skills, since processing unrelated or excessive information can reduce the capacity of cognitive working memory (Paas, Renkl, & Sweller, 2003).

Psychological factors like learner attitude toward computers and computer anxiety can also affect academic achievement. Although there have been many empirical investigations related to the effects of computer anxiety on learning and attitudes toward the learning process in digital settings, the findings are somewhat inconsistent. For instance, Piccoli, Ahmad, and Ives (2001) found that computer anxiety has a direct impact on learner satisfaction in web-based virtual learning environments. On the other hand, Tallent-Runnels et al. (2006) showed that computer anxiety does not affect student performance in online settings. Nonetheless, positive attitudes toward using computers may contribute to a greater satisfaction with computer-assisted learning, while negative attitudes may inhibit learning and even decrease interest in the learning process and consequently lower learner satisfaction (Sun, Tsai, Finger, Chen, & Yeh, 2008).

Environmental or external factors like teacher engagement and attitude, clarity of instruction and performance expectations, social values, and available technical support can also influence learning outcomes and learner satisfaction (Keller, 2008a, 2008b; Sun et al., 2008). Well-designed online courses increase student learning and contribute to higher satisfaction with the coursework (Tallent-Runnels et al., 2006). Furthermore, instructors' prompt response positively correlates with student satisfaction in online settings (e.g., Arbaugh, 2002).

Much has been written about the motivational factors that can affect human performance in digital learning environments. One of the more comprehensive and empirically validated motivational theories, the ARCS model (Keller, 1999), identifies four dimensions of motivation – Attention, Relevance, Confidence, and Satisfaction – and all can directly affect student motivation independently (Keller, 2008b; Naime-Diffenbach, 1991). Student attention can be gained by both the novelty and graphic design attractiveness of a digital learning environment or any other technique that stimulates student curiosity (Attention). In order to sustain that aroused attention throughout the full learning process, these learning materials should (a) present new knowledge and skills in a meaningful way to establish a clear connection with the learners' goals, values, and experiences (Relevance) and (b) develop positive student expectancies of success (Confidence). Successful completion of tasks presented in the learning environment and acquisition of new knowledge and skills also will influence student attitudes toward the instruction being received (Satisfaction). By carefully assessing and regulating each of these components, educators and researchers can facilitate student motivation and promote positive learning outcomes.

One of the most vivid examples of learning environments that can facilitate learning by mediating learner motivation is instructional video games (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Other examples of motivational research in digital settings include self-efficacy (Bandura, 1977) and flow experience (Csikszentmihalyi, 1990). Self-efficacy is a significant factor for determining student behavior. The more confident learners are in their ability to perform a specific task, the more time and energy they will devote to that learning process (Liaw, 2002). Research has demonstrated that the quality of a computer-based learning environment is a more powerful predictor of self-efficacy than the total amount of time that learners spend on computer-based activities (Ertmer, Evenbeck, Cannamo, & Lehman, 1994). The effects of flow experience or the degree to which a learner feels absorbed in a particular activity on tasks outcomes have been extensively discussed in the literature. Flow can mediate the effects of instructional interventions on task performance and also promote satisfaction of the learner with the learning experience (Schaik & Ling, 2012).

Although high motivation can facilitate effective learning, many learners often need to invest additional effort and employ self-control strategies to stay on task and overcome different kinds of distractions. Such self-control or volitional strategies can be beneficial for student performance when threats to motivation are present (Kim & Keller, 2008).

2. Keller's integrative theory of Motivation, Volition, and Performance

In order to understand the relationships that exist between the theories related to motivation, volition, learning, and performance, Keller (2008a, 2008b) proposed an integrative theory of Motivation, Volition, and Performance (MVP). He argued that examining how different theories interact with each other and work together could be more beneficial for advancing research and practice than focusing on single theories that examine isolated constructs. Keller used the ARCS model of motivational design to explain motivational dimensions as these relate to learning and performance. The first three components of the ARCS model, i.e., (1) a person's interest and curiosity about learning ("attention"), (2) learning goals or values ("relevance"), and (3) expectations of perceived success ("confidence") represent learning conditions. The fourth ARCS component, satisfaction, is viewed as a learning outcome or the product of the learner's mental evaluation of her/his achievement level given learner's ability to apply the newly acquired skills and knowledge to everyday life.

Since each of these four components can influence learning and performance, Keller (2008a) presents them as an integrative model of motivation, learning, and performance to emphasize the interrelationships that exist between the motivational and the actual learning processes (Fig. 1). Building on this established motivation, learning and performance model, Keller expanded it into the MVP model by integrating additional theories that include action control (Kuhl, 1987), self-regulation (Zimmerman, 1998), implementation intentions (Gollwitzer, 1999), cognitive load theory (Paas et al., 2003), and information processing theory (Astleitner & Wiesner, 2004; Atkinson & Schiffrin, 1971; Mayer, 2001). The MVP theory thus creates a comprehensive framework for investigating the relationships that exists among the different cognitive and non-cognitive processing variables that can affect student performance, i.e., the total outcome of learning. Student performance or achievement is an observable behavior clearly affected by various environmental, psychological, genetic, and sociological factors. Once a certain performance level is achieved, that accomplishment evokes a mental evaluation of the consequences of that performance or gaps between the current and the desired performance levels. This evaluation influences learners' final satisfaction with the learning process and its outcomes (see Fig. 2).