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A multi-user virtual environment to support students' self-efficacy and interest in science: A latent growth model analysis

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A B S T R A C T

Using latent growth models, we explored: (a) The effect of middle school students' (n = 189) pre-intervention science self-efficacy and science interest on their initial interest in an Ecosystems Multi-User Virtual Environment (EcoMUVE) and the rate of change in their interest in EcoMUVE; and (b) the mediating effect of students' initial interest in EcoMUVE and rate of change in interest on students' post-intervention science self-efficacy and interest in science. Results showed that: (1) students' pre-intervention self-efficacy for science had an effect both on students' triggered situational interest for EcoMUVE and on students' maintained situational interest for EcoMUVE; (2) *both* triggering and maintaining situational interest in EcoMUVE were important in developing students' science self-efficacy. In fact, maintained situational interest was the stronger predictor; and (3) maintained situational interest for EcoMUVE translated into individual interest for the *science content*. Results support and extend social cognitive theory as well as models of interest development.

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1. Rationale

Although immersive technologies like games and simulations have the potential to serve as a "hook" for students' interest in academic activities, some research has shown that the effects of participating in the technology activity on students' academic interests are often short-lived because the novelty of the technology wears out quickly (Clark, 1983; Deaney, Ruthven, & Hennessy, 2003; Moos & Marroquin, 2010), or that students' interests in the *technology activity* do not transfer to students' interests in the *academic subject* (Torff & Tirotta, 2010). Other studies have also shown that technology-rich activities, especially highly immersive ones, can even distract students from the salient academic content, thereby interfering with students' motivation and learning (Adams, Mayer, MacNamara, Koenig, & Wainess, 2012; Moreno & Mayer, 2004).

Despite these findings that technology-rich activities can often thwart meaningful learning and motivation, Multi-User Virtual Environments (MUVE) that simulate the types of scientific reasoning that actual scientists enact can potentially support and bolster students' motivation in science (cf., Barab, Gresalfi, & Ingram-Goble, 2010; Chen, Metcalf, & Tutwiler, 2014; Ketelhut, 2007). We base this premise on theories of motivation that outline the necessary conditions that develop students' competence beliefs (i.e., "Can I succeed in this activity?") and their value beliefs (i.e., "Is this activity enjoyable or useful to me?"). These conditions include providing (a) opportunities to successfully accomplish increasingly more complicated tasks; (b) meaningful choices of goals for students to pursue; and (c) opportunities to work collaboratively with others. Furthermore, past studies with an Ecosystems MUVE (EcoMUVE) have shown that, although students were initially drawn to the novelty of the technology, and that the novelty did wear off over time (Metcalf et al., 2014), students' interest development in science over the course of the intervention differed based on the degree to which they identified with science (Chen et al., 2014). Therefore, technology-rich environments that allow students to use salient scientific knowledge and skills to enact the types of scientific reasoning skills that scientists enact may be an effective way to create *situational interest* (SI) with the technology activity, which Hidi and Renninger (2006) defined as "focused attention and the affective reaction that is triggered in the moment

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by environmental stimuli, which may or may not last over time" (p. 113). We posit that this SI for the technology activity, which in our case is generated by immersing students in a collaborative game-like task that simulates in a fun way how scientists think through complex problems, can foster the development of students' more enduring *individual interests*, which Hidi and Renninger defined as "a person's relatively enduring predisposition to reengage particular content over time" (p. 113). This has been an ongoing challenge for designers and educators—to create engaging technology-rich activities that allow students to transfer their excitement for the technology-based activity into an enduring interest in science.

Our overall goal was to extend the literature concerning the development of situational interest into individual interest within text-based tasks to more complex scenarios involving technology-rich contexts that simulate the type of intellectual reasoning that scientists perform in real life. Given that the majority of research exploring the development of interest has been done in text-based tasks, there is a great need to move beyond these tasks to more complex, naturalistic, classroom-based tasks, especially those involving technology-rich activities. There is reason to believe that the motivational dynamics between interest and self-efficacy are different for learning environments such as EcoMUVE compared to reading texts. For example, tasks within programs like EcoMUVE are quite complicated—often done in collaboration with others, and involving many self-directed tasks in which students have to recruit a large variety of cognitive resources to solve complex problems. The stimuli that are present to both trigger and maintain SI within such learning environments like EcoMUVE can potentially be much more diverse and intense than those presented in text-based tasks.

Another goal was to explore "profiles" of triggered and maintained SI for a technology-rich activity that relate to the development of students' individual interests in a subject. These profiles were formed using latent growth analysis, which modeled the combination of students' initial interest in EcoMUVE (i.e., triggered SI in EcoMUVE) and their rate of change in EcoMUVE interest (i.e., maintained SI in EcoMUVE). This "interest profile" was modeled as a mediator of students' pre-intervention science self-efficacy and interest on their post-intervention self-efficacy and interest. By modeling SI in this way, we were able to explore the interest profiles that do and do not translate SI for a technology-based activity into individual interest for a subject—a problem that has plagued instructional design for years. We next situate this phenomenon in the interest development literature.

2. Theoretical framework

2.1. Interest and its development

Although technology-rich activities are often seen as a key component in motivating and engaging today's 21st Century learners, there are legitimate critiques of this generalization (Chen, Zap, & Dede, 2012, 2009; Moos & Marroquin, 2010). Immersive technology-based activities are often criticized as being capable of only generating interests for novel aspects of the technology itself rather than in a subject area—eliciting a novelty effect (Clark, 1983; Moos & Marroquin, 2010). Once the novelty of the technology wears off, students' interests in both the technology and the subject likely diminish. However, recent research has indicated pedagogical elements of technology-rich activities employing strong design and pedagogy can overcome technology's novelty effect (see Dalgarno & Lee, 2010). In fact, we posit that technology-rich activities that allow students sufficient autonomy to explore a problem, provide virtual tools allowing students to gain competence in collecting and analyzing information, and couch the process of scientific inquiry in a meaningful and fun context can facilitate the development of students' interests with technology-based activities into more enduring interests with a subject. We hypothesize that, although a novelty effect for the technology may be exhibited, there may be a corresponding increase in students' interest in science.

Hidi and Renninger (2006) four-phase model of interest development outlines how students develop their nascent interest in a particular activity into more enduring interests in a larger field of study. In their model, they hypothesized an initial phase in which interest is *triggered*, usually temporarily by environmental cues like surprising information or personally relevant contexts. The second phase is called *maintained situational interest* in which SI is sustained through meaningful tasks and/or personal involvement. In a third phase students can begin to form an enduring inclination toward reengaging with activities for a subject area. This *emerging individual interest* is characterized by stored knowledge, value, and positive affect. Finally, when individuals attain a *well-developed individual interest*, they exhibit positive affect, have a more robust stored knowledge and value for the subject, and are able to reengage in activities related to the subject on their own volition.

Within the four-phase model of interest development, the novelty effect is a phenomenon in which interest for a novel learning environment (e.g., our technology-related activity) is triggered. However, over time (10 days, in our case) this interest fades—SI is not maintained. Because EcoMUVE was designed to support and develop students' knowledge and skills related to scientific inquiry (see Appendix A for a detailed description), fading of triggered SI for EcoMUVE likely means that individual interest for the subject of science also suffers. However, if triggered SI for EcoMUVE is maintained, students' interest for science is more likely to benefit.

The mechanisms responsible for translating SI for an activity into individual interest for a subject are not fully understood. However, some studies provide a few possibilities. First, students' individual interest can be considered a motivational resource on which students can draw during uninteresting tasks (Katz, Assor, Kanat-Maymon, & Bereby-Meyer, 2006; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Therefore, more stable characteristics such as individual interest may be strong enough to surpass the effects of an uninteresting task.

Other studies, however, have suggested that features of the learning environment (rather than more stable individual differences) can trigger and maintain students' interest in an activity, and then develop into more enduring individual interest. These studies have shown that novelty (Palmer, 2009), task concreteness (Tapola, Veermans, & Niemivirta, 2013), and stressing the relevance of a task (Hulleman, Godes, Hendricks, & Harackiewicz, 2010) can develop students' SI into more enduring individual interests. Recently, Rotgans and Schmidt (2014) suggested that learning materials are more effective at eliciting and maintaining SI when they present students with a surprising problem that highlights a gap in students' knowledge. Furthermore, from a self-determination perspective, Ryan and Deci (2000) argued that providing students with choices, building a sense of relatedness, and providing supports for their growing competence are all necessary for developing SI into more enduring forms of individual interest. In fact, Ryan and Deci argued that, "relatedness, the need to feel belongingness and connectedness with others, is centrally important for internalization" (p. 73). They also argued that, "support for autonomy allows individuals to actively transform values into their own" (p. 74). In essence, internalization (i.e., the "taking in" of a value or regulation) and integration (i.e., transforming those values and regulations into one's own sense of self) are critical in developing individuals' enduring individual interests.

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