Motivational Feedback Designs for Frustration in a Simulation-based Combat Medic Training Environment

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INTRODUCTION

Tutoring systems researchers have recognized the need to identify and address affective states that lead to disengagement in learning activities (Baker, D'Mello, Rodrigo, & Graesser, 2010; D'Mello, Lehman, & Graesser, 2011; D'Mello Strain, Olney, & Graesser, 2013; Forbes-Riley, Litman, Friedberg, 2011; Gee, 2004, 2007; Picard et al., 2004). Some affective states have relatively uncomplicated relationships with student learning outcomes – engaged concentration appears to be positively associated (Craig et al., 2004; Pardos et al., 2014) while boredom is negatively associated (Craig et al., 2004; Pardos et al., 2014). The affective state of frustration is more complex. Liu and colleagues (2013) have found that brief frustration is not problematic, but that extended frustration is associated with worse learning outcomes. Understanding how intelligent tutoring system can respond to frustration is likely to be an important aspect of future affect-sensitive learning environments (Picard et al., 2004).

In this paper, we discuss potential intervention designs that will be used in upcoming research on how intelligent learning environments can respond to student frustration. These designs will be embedded in the context of the GIFT architecture (Sottilare, Goldberg, Brawner, & Holden, 2012), designed for the context of using the TC3 courseware and vMedic serious game (Sotomayor, 2010) focusing specifically on game-based training materials for hemorrhage control. Three designs will be presented in this paper; the designs are informed by three theories on learner motivation, specifically control-value theory (Pekrun, 2000), social identity theory (Tajfel & Turner, 1979), and theory of self-efficacy (Bandura, 1977). By studying designs connected to three distinct theoretical paradigms, we can investigate which theoretical paradigm is most useful for driving the design of adaptations to frustration. Adapting to learner frustration depends on knowing which students are frustrated. To this end, this project builds on prior work on the detection of affect in vMedic. In this work, baseline data was collected in September 2013 on learner engagement and affect while trainees were learning about hemorrhage control through vMedic. This baseline data was used to develop affect detectors for frustration using both interaction-based and posture-based approaches (Paquette et al., accepted).

The next task in these efforts is to design intervention messages aimed at improving trainee engagement and learning outcomes, leveraging the information provided by automated detection of affect. As such, we will examine the impact of motivational feedback messages, incorporated into vMedic. Developing frustration feedback interventions, and studying their impact on learning, will contribute to a greater understanding of the relationship between affect, engagement, and learning outcomes, and how negative affect can be addressed by automated systems. In the long term, this effort will help us understand how to design affect-sensitive tutoring systems, realized within the GIFT architecture.

THEORY AND PREVIOUS RESEARCH

Frustration and learning

As discussed above, the relationship between frustration and engagement is complex. While negative relationships between frustration and learning are not always seen (e.g. Craig et al., 2004; Pardos et

al., 2014), some studies have suggested that this is because the duration of frustration matters more than its absolute incidence (e.g. Liu et al., 2013). Beyond just learning, frustration has been found to divert student attention from learning tasks and lead the learner to worry excessively about failure (Kapoor, Burleson, & Picard, 2007; McQuiggan, Lee, & Lester, 2007). In the specific context of vMedic, unpublished early research suggests that frustration is negatively correlated with learning outcomes, making it important to study in this context.

The dynamic nature of frustration – where brief frustration can yield positive learning gains but sustained frustration yields negative outcomes (Liu et al., 2013), a pattern also seen for the related affective state of confusion (Lee et al., 2011; Liu et al., 2013; D'Mello, Lehman, Pekrun, & Graesser, 2014) – requires interventions that are timely.

Motivating the learner to persist through frustration

Appropriately responding to student frustration depends on understanding the nature of the type of intervention that will be utilized. In this paper, we focus on feedback messages, which are easy to implement in the GIFT architecture, and which can be generalized with relative ease within that architecture. Narciss (2008) notes that motivational feedback can be conducted with many purposes, one of which is to sustain effort and persistence in the learning task. This feedback model contextualizes feedback within the theories of self-regulated learning where the primary function of feedback is guiding the learner to successfully regulate their learning process (Butler & Winne, 1995; Narciss, 2008). Narciss (2008) maintains that feedback that guides learners to successful task completion through motivating them rather than immediately providing answers of correct responses can provide a learner with a mastery experience, leading to the development of positive self-efficacy (Bandura, 1997; Usher & Pajares, 2006).

Designing computational systems that can both recognize when a learner is frustrated provide an effective intervention, which positively impacts the learner's future actions and their learning outcomes, is a complicated process. Thus far, research in alleviating frustration through feedback messages has achieved mixed results (Klein, Moon, & Picard, 2002; Robison, McQuiggan, & Lester, 2009), emphasizing the importance of selecting interventions that have low probability of negative consequences to learners (Robison et al., 2009). As such, it is important to attempt to deliver motivational feedback for frustration at the right time, and to select interventions that have limited cost if incorrectly applied.

PROJECT DESIGN: FRUSTRATION FEEDBACK INTERVENTIONS

Within GIFT, motivational feedback messages will be authored as both a text and an audio message to be delivered by an embodied pedagogical agent once the frustration detectors, built into GIFT, detect frustration of the trainee. We will compare three types of motivational feedback, plus a control condition, making a total of four conditions: one condition providing messages designed according to control-value theory, one condition providing messages designed according to social-identity theory, one condition providing messages designed according to self-efficacy theory, and a control condition with no feedback messages. For each of the feedback conditions, a separate message will be authored for each of the four scenarios the trainees will complete while engaged with vMedic. These messages will be delivered via the GIFT architecture, appearing to be given by a pedagogical agent (cf. Klein et al., 2002).

Control-value Theory

One path to intervening on frustration involves framing feedback messages within the context of control-value theory (Pekrun 2000, 2006). The objectives of this feedback are to 1) seek to motivate learners to persist in the learning activity based on an implicit appeal to the learner's perceived controllability of achievement activities and their outcomes, as well as 2) highlight the value and importance of the learning activities and outcomes (Artino, Holmboe, & Durning, 2012). Control-value theory was developed by Pekrun (2000, 2006) as a comprehensive, integrative approach to understanding emotions in education. When individuals feel in or out of control of achievement activities and outcomes that are subjectively important to them, they experience specific achievement emotions (Pekrun, Frenzel, Goetz, & Perry, 2007). Achievement activities are mediated by emotions that influence cognitive resources, motivation, strategy choices, and intrinsic and extrinsic regulation of learning. The outcome of these achievement activities in turn influences students' emotions (Pekrun, Frenzel, Goetz, & Perry, 2007).

Control-value theory, then, implies that student achievement emotions such as frustration can be influenced by changing the student's subjective perception of control and value through a shaping of the learning environment (Pekrun, Frenzel, Goetz, & Perry, 2007; Kim, 2010). In the specific case of this study, we will influence trainees' perception of control and value using feedback messages that include facts pulled from journal papers on the effectiveness of using relevant medical procedures that can be applied in the field such as tourniquets for hemorrhage control, suggesting that participants can control casualty outcomes through their actions, creating positive outcomes that they value (survival of a fellow soldier). An example of a feedback message in this condition includes the following: "Studies have shown that between 17% - 19% of deaths in Vietnam could have been prevented if tourniquets had been used," (DePillis, 2013).

Social Identity Theory

A second path to intervening on frustration involves framing feedback messages to highlight the trainee's role as a member of a group, in this case, as a member of the United States Army. This design capitalizes on social identity theory, which states that our identities are formed in large part through the groups to which we belong, creating some degree of uniformity of perception and action among group members (Stets & Burke, 2000). While the authors have not identified literature on using social identity feedback messages to address frustration in tutoring systems, social identity theory has been used to motivate human-human training to shape behavior and decision-making, including attitudes and value-orientations – particularly in the education and training of military cadets at West Point (Franke, 1997; Franke, 2000). The existing use of this approach in military training highlights its potential value for automated adaptation designed for this population.

Shamir, House, and Arthur (1993) have argued that leaders strengthen social identification through the use of cultural symbols such as slogans, symbols, rituals, and ceremonies that highlight collective identity, superiority, and uniqueness. Taking into consideration, then, the relationship between cultural slogans and a soldier's social identity, the second feedback condition was chosen in the form of quotes by former Generals, identifying the learner as a "soldier" and calling on the learner's identification as a member of the US Army. These identity-based motivational feedback messages highlight how to handle frustration, and the importance of persistence in the face of frustration. The messages are connected to military leaders in order to capitalize on the notion that people prefer actions that are identity-congruent (Oyserman & Destin, 2010). An example of a feedback message in this condition includes the following: " 'Duty, Honor, Country' — those three hallowed words reverently dictate what you ought to be, what you can be, what you will be.' -- General Douglas MacArthur, Jr." (MacArthur & Westmoreland, 1964).

Self-Efficacy Theory

A third path to intervening on frustration involves framing feedback messages based on the theory of self-efficacy, directed at the learner as an individual, and their ability to succeed in the task if they persist. Self-efficacy is known to correlate positively to academic performance and persistence rates (Bong, 2001; Kaun & Nauta, 2001; Multon, Brown, & Lent, 1991; Wood & Locke, 1987) – this intervention will test if it can address frustration as well.

Bandura's (1986) socio-cognitive perspective on the role of self-efficacy theorizes that individuals are proactive and self-regulating rather than merely reactive and controlled by biological or environmental forces. Bandura's social cognitive theory (1997, 2002) argues that perceived self-efficacy influences a person's motivation for tasks, actions towards goal achievement, perseverance on tasks, and responses to failures.

For the purposes of using the self-efficacy construct to inform the design of feedback messages, the goal is to design feedback that persuades the learner they have the necessary skills to succeed. As such, the feedback messages informed by the theory of self-efficacy will be designed to support the trainee's belief that they can succeed in the system and attain their learning goals while engaged in vMedic. An example of a feedback message in this condition includes the following: "Your best outcomes will be achieved if you persist."

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

In this article, we discuss our efforts to design feedback that can address trainee frustration, within the context of vMedic. We articulate three potential designs for feedback, based on three relevant theories: control-value theory, social-cognitive theory, and self-efficacy theory. We will investigate the impact of these interventions through a study where these feedback messages are delivered by a pedagogical agent embedded in the GIFT architecture, executed within the vMedic training system. The findings of this study, it is hoped, will shed light on how to develop affect-responsive tutoring systems for U.S. Army personnel. By creating online training that is sensitive to trainee affect, and helping trainees learn to regulate their behavior better in frustrating situations, we can take a step towards online training that better prepares U.S. Army soldiers for the many challenges they will face.

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