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Interactions between emotion regulation, intelligent tutoring systems, and learning styles

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Introduction: Recently, interest has increased in the development of new technologies to support STEM learning, such as intelligent tutoring systems and virtual laboratories, which aim to make students active, embodied learners rather than passive receivers of information. However, a key question remains: how to keep students engaged? The group I am presently working with at the University of Memphis (UofM), under the direction of Sidney D'Mello, Art Graesser, and Andrew Olney, is systematically investigating this exact issue. We are studying how mechanisms such as text difficulty and learner interest facilitate or hinder engagement, with the goal of developing interventions to promote productive engagement trajectories during learning. In addition, recent work on affect-sensitive learning technologies [3] and affect trajectories during complex learning [2] suggests that affect-sensitive agents can improve learning gains. A promising next step is to tie external interventions from an intelligent learning interface to internal interventions by the learner via emotion regulation strategies. Other recent work suggests that intelligent tutoring robots benefit learners [1][5]. A worthwhile comparison will be to evaluate the effectiveness of the "embodied robotic" tutoring system as opposed to a virtual agent, in the context of increasing learner engagement and targeting different learning styles.

Proposed study and hypotheses: This study will investigate how emotion regulation strategies, such as cognitive reappraisal and attentional deployment, can be coupled with dynamic interventions by an intelligent learning interface to promote engagement and increase learning gains. Engagement and other emotions will be tracked via self-report measures, eye tracking, and recently developed affect sensing technologies. The learning interface will dynamically adapt to the individual learner,'s needs e.g., by selecting learning activities and materials to optimize learner engagement and by adapting the style of interaction.

Based on prior work on cognitive appraisal during learning (e.g., [9][10]), it is anticipated that utilizing emotion regulation methods will improve learning. It is an open question whether methods that are consciously taught work better than, e.g., implicitly re-directing the student's attention. It is hypothesized that the dynamic selection of learning activities and topics will improve engagement, since it is likely that learners will be more engaged and motivated to learn when the topic they are learning is personally relevant. In addition, placing the tutoring agent in a robot will afford the learner different kinds of learning experiences, which is hypothesized to increase engagement for aural and kinesthetic learners more than visual and read/write learners [6].

Research plan: The experiment will use a 3x2 (emotion regulation x learning interface) within subjects design. Emotion regulation will have three levels: (1) instructed cognitive reappraisal, (2) an effortful, non-reappraisal task, and (3) control. The learning interface will be either the virtual tutoring agent or the embodied robot tutor. The tutoring session will cover topics on critical thinking and scientific reasoning, based on materials and texts already developed for AutoTutor [4]. Cognitive reappraisal was chosen as the emotion regulation method, because this method has successfully been used to increase learning gains [9][10]. In future studies, alternative emotion regulation methods will be tested and evaluated.

Participants will be initially recruited from undergraduate student populations. They will sign an informed consent form, then complete a brief demographics questionnaire and a pretest measuring knowledge of scientific inquiry topics. They will then complete a learning session with one of the tutoring agents. Periodically, engagement measures including a self-report of engagement levels and current affective state via the Affect Grid [8] will be collected, as well as continuous galvanic skin response, gaze patterns, and video of face for offline analyses. After the learning session, participants will complete a post-test that is a counterbalanced version of the pretest. Individual difference measures will be collected during a second session one week later, including a delayed post-test measuring long-term knowledge retention and a battery of validated questionnaires, such as measures of learning-related affective traits via the Achievement Emotions Questionnaire [7], and learning styles via the VARK Learning Styles Inventory [6].

The virtual tutoring agent will extend the existing AutoTutor interface [4]. The embodied robot agent will use a similar interface, but will, e.g., use voice input instead of text, drawing on previous robotic tutor work [1][5]. Affect-detection techniques currently under development at UofM will be used to ensure that both agents will be able to detect and adaptively respond to different learners, drawing in from biologically-inspired methods of adaptive response, e.g., using emotion-like systems to influence action selection and to direct the agent's attention to relevant aspects of the learner's environment. Small studies of 10-15 participants will be conducted to validate the agents' helpfulness and responsiveness.

Data analysis will focus on determining how the learning interface influences engagement and learning, how individual differences impact the effect of emotion regulation strategies, and how the learning interface and emotion regulation strategies interact.

Anticipated results: This research aspires to understand how learners can influence their own learning and engagement, and how the context of learning and means by which information is conveyed impact learning. It is anticipated that an intelligent tutoring system that can tailor itself to the learner will increase both learning gains and overall engagement, and that learners who discover that they can influence their own learning (via, e.g., emotion regulation) will benefit most. The insights gained will be leveraged for the development of learning environments for scientific literacy, given how important it is for individuals to have a solid foundation in scientific knowledge and inquiry, and could be extensible to any other subject matter. If initial studies are promising, wider-scale testing of the learning interfaces will be conducted in schools, with an emphasis on schools in lower socio-economic regions and with populations that are generally underrepresented in science.

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