International Society of the Learning Sciences

Transmuting Intellectual Liabilities into Assets for Engagement

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Abstract: Learners' emotional experiences can lead to disciplinary engagement or abandonment. We aimed to determine how students early emotional experiences when learning during discomfort can be transmuted from liabilities into assets that promote engagement. To accomplish this aim we combine theories from Positive Psychology and Knowledge-in-Pieces. We triangulate surveys, clinical interviews, and physiological data (EDA) to determine the psychological mechanisms that underpin disciplinary engagement.

Introduction

Science reflects an endeavor that entails emotion. Students' emotions illuminate their science engagement (Jaber & Hammer, 2016). We aim to build theory about the psychological mechanisms that underpin students' *epistemic affect*—i.e., feeling during science practice—by leveraging a scale down approach (Nathan & Alibali, 2010). This approach complements prior multimodal analytic approaches that leveraged speech and gesture by combining these modes with physiological measures (Lee, 2021). The research holds the distal goal to (1) determine complementary relations between Positive Psychology and Knowledge-in-Pieces (KiP) theory and (2) design biofeedback interventions that facilitate students' engagement when learning challenging STEM content.

Theoretical framework: A knowledge resources approach

We offer a psychological model that combines two traditions: Intellectual Humility (IH) from Positive Psychology and Knowledge Resources from the Learning Sciences. IH refers to a person's disposition toward owning their own intellectual limitations in a domain, e.g., science (McElroy-Heltzel et al., 2019). Extant approaches assess this construct via survey methods. In contrast, Resources approaches assess students via disciplinary tasks often completed in clinical interviews (Russ, Lee, & Sherin, 2012). Resources approaches provide theoretical machinery for characterizing mechanisms of change during students' science engagement. Here we use the construct *epistemic affect* (Jaber & Hammer, 2016)—or the emotions that students display when participating in STEM activities. Thus, we aim to determine how IH predicts students' enacted epistemic affect.

Drawing upon advances in multi-modal learning analytics

Many factors contribute to undergraduate students abandoning STEM majors, but sometimes this occurs because discomforting thoughts and feelings accumulate during their course work (Danielak, 2022). We aim to identify how students' thoughts and emotions manifest during short time scales to explain how students' epistemic affect relates to their academic outcomes. One challenge, however, is that learners' thoughts and feelings are not always visible. To our fortune, innovations in physiological measures grant insight into learners' cognitive and affective states (Lee, 2021). Although these technologies do not offer direct insight into learners' mental processes, they capture otherwise unobservable changes in learners' physiological arousal states. If combined with other measures and interpreted in context, measures such as Electrodermal Activity (EDA) assess engagement.

These advances in multi-modal learning analytics bridge IH and KiP. Individual differences approaches gather demographic risk factors that predict downstream failure and attrition. These approaches, however, fail to determine the social, cognitive, or emotional mechanisms responsible for these outcomes. KiP approaches leave unknown the critical role that these individual differences play prior to STEM instruction. We therefore combine IH survey scales with KiP interview approaches. These surveys assess students' professed beliefs regarding their willingness to persist during intellectual discomfort. They therefore offer potential predictors of engagement, but these surveys are decontextualized and are therefore suspect. EDA data responds to both limitations by assessing covert engagement not detecting by either approach. We therefore ask: How do learners with different professed IH enact intellectual engagement via overt (affect) and covert (EDA) measures?

Preliminary results and discussion

Students (N=8) participated in an interview after first completing a survey (N=73). A sampling method identified two students who professed Low and High IH relative to their peers (Figure 1). A mathematical reasoning task illustrated that the student who reported High IH (7.33) produced several behavioral markers that indicated

productive engagement compared to the student who reported Low IH (4.75). Although both students failed to solve the problem, the High IH student promptly made attempts whereas the Low IH student requested clarity throughout the task ("What you are asking me is […] I do not know how to say it"). Moreover, the High IH student identified a strategy that avoided confirmation bias (i.e., "I need to guess numbers that do *not* conform to the rule") whereas the Low IH student did not. She also produced more positive facial expressions (12 to 6 smiles), and she *accepted* being told the answer as opposed to *asking* for the experimenter to give it to her. When told the answer, the High IH student responded, "Oh, OK," whereas the Low IH student responded, "Oh my God, that was not what I was thinking at all." Regarding EDA measures, we used a change-point detection principle for data segmentation (Hawkins & Zamba, 2005). The change-point detection determined that the High IH student showed low variability relative to the Low and Moderate IH peers—this means that the High IH student maintained more stable EDA for longer durations and produced fewer "peaks" with lower relative amplitudes.

Figure 1

Students' Affective Display, Talk, EDA Response, and Professed IH, Respectively

This contrasting case analysis reveals that learners enact their professed intellectual humility (IH) during interviews through distinct overt and covert actions that include affective displays comparable to epistemic affect markers observed by Jaber and Hammer (2016). This pattern aligns with Russ, Lee, and Sherin (2012) who identified students' distinct epistemic framing profiles based on overt actions during interviews (e.g., body position). These overt engagement markers were supported by covert EDA measures. Students' professed IH predicted distinct EDA profiles. This pattern suggests that although the Learning Sciences prefers situated action over decontextualized self-report, self-report can provide valuable engagement predictors. Self-report predictors offer insights for designing learning interventions tailored to populations with diverse affective needs. Furthermore, *overt* affective engagement markers correspond to distinct EDA profiles that indicate *covert* engagement—complementing Lee's (2021) findings. This hints that in learning tasks where overt actions are not elicited, correlations between students' professed IH and their covert engagement exist. Therefore, students' professed IH and covert engagement reveal aspects of learning during discomfort that may be overlooked by assessments focusing solely on overt engagement—especially in passive learning environments.

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