Embodiment as Evidence for Student Engagement in an Inquiry-Based Mathematics Classroom

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Keywords: Embodiment, inquiry, engagement

The multi-dimensional construct of student engagement is an important aspect of students' experiences with mathematics, and increased levels of engagement support students' academic achievement (Carini et. al, 2006; Pilotti et al., 2017) and positive mathematics identity (Voigt et al., 2022). We propose that embodiment is a useful lens for exploring evidence of such engagement. Embodiment is the notion that "thinking does not occur solely in the head but also in and through a sophisticated semiotic coordination of speech, body, gestures, symbols and tools" (Radford, 2009, p. 111). While scholars have studied student engagement in the context of specific embodied tasks through self-reporting instruments (Georgiou & Iannou, 2020; Lindgren et. al, 2016), there is a gap in the literature regarding how embodiment might provide evidence of students' engagement. As student engagement with meaningful mathematical tasks is one of four pillars of Inquiry-Based Mathematics Education (IBME) (Laursen & Rasmussen, 2019), the IBME classroom is an ideal setting to study observable, embodied student engagement. In this poster, we present a microanalysis of three episodes of embodied engagement between two students (Rebecca and Lauren) in an IBME Discrete Mathematics classroom.

We draw on Fredericks et al.'s (2004) summaries of *behavioral* (on-task, participatory classroom actions), *affective* (emotional response or investment to the task at hand and its associated discoveries), and *cognitive* (students' self-regulation of learning) engagement to assess whether embodiment captures classroom engagement. These categories of engagement are not disparate, and thus we consider them as "dynamically interrelated" (Fredericks et al., 2004, p. 61). We also leverage definitions of embodiment that draw from Nemirovsky et. al (2012) in which mathematics is framed as a perception-action cycle and is evidenced by bodily activities including gesture, gaze, and body position to address our research question: *In what ways can embodiment provide evidence for students' engagement with meaningful mathematical tasks?*

Our three selected episodes support the notion that all three categories of student engagement are observable, embodied phenomena in the IBME mathematics classroom. For example, in one episode Rebecca's body positioning, gesture, and use of materials, without verbiage, illustrates her behavioral and cognitive engagement as the professor and Lauren converse. An embodied lens enabled attention to Rebecca's rich engagement that otherwise may have gone unnoticed. Thus, we assert that leveraging embodiment to study student engagement provides new insights into how students engage with meaningful tasks in an IBME classroom. This perspective can be utilized by both researchers and instructors in constructing a more nuanced understanding of how students engage with mathematics tasks.

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Embodiment as Evidence for Student Engagement in an Inquiry-Oriented Mathematics Classroom

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Motivation

Engagement in the math classroom is an important component of student experience and achievement. (Carini et al., 2006; Pilotti et al., 2017; Voigt et al., 2022)

"Developing valid and reliable measures [for student engagement] is especially important in math and science because **engagement** in these subjects **is so critical to academic achievement and career choices** related to STEM." (Fredericks et al., 2016)

Measuring student engagement is often limited to self-reporting or observation scales which privilege verbal participation. (Fredericks & McColskey, 2012; Hodgson et al., 2010)

We propose embodiment as a lens through which to observe student engagement in the classroom,

Research Question: In what ways can embodiment provide evidence for students' engagement with meaningful mathematical tasks?

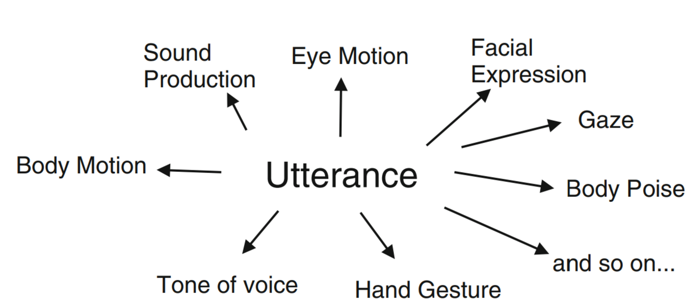
Embodied Cognition

Embodied cognition asserts that "…thinking does not occur solely in the head but also in and through a sophisticated semiotic coordination of speech, body, gestures, symbols and tools." (Radford, 2009, p. 111)

Embodiment can *enhance* student engagement with tasks. (Georgiou & Iannou, 2020; Lindgren et al., 2016)

We categorized the embodiment of our participants using Nemirovsky and Ferrara's (2009) notion of **multimodal utterances.**

Nemirovsky & Ferrara (2009)
Figure 2: The multimodality of an utterance



Student Engagement

Fredericks et al. (2004) provide three categories of student engagement:

- **Behavioral Engagement:** on-task, participatory classroom actions
- **Affective Engagement:** emotional response and investment in the task
- **Cognitive Engagement:** students' self-regulation of learning, thoughts, and perseverance

Student engagement with meaningful mathematics tasks is one of four pillars of Inquiry-Based Mathematics Education (IBME). (Laursen & Rasmussen, 2019)

Methodology

Participants:

- Students of an undergraduate Discrete Mathematics course
- An experienced instructor (Dr. A) who follows an Inquiry-Based Mathematics Education (IBME) teaching paradigm

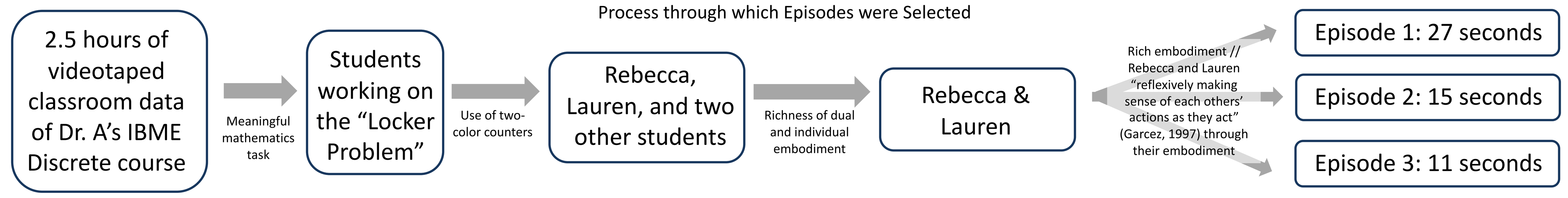
Data Collection and Selection:

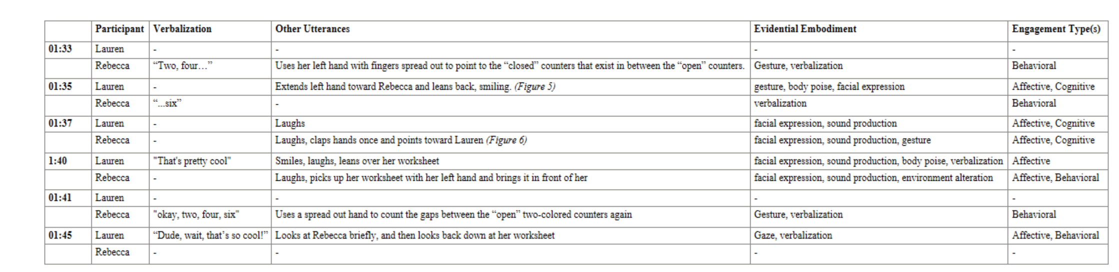
- Videotaped a total of 2.5 hours of classroom footage
- Narrowed our focus to a *meaningful mathematical task* that the students worked on the "Locker Problem" *(physical copy of worksheet available for viewing)*
- Analyzed the engagement of two students, Rebecca and Lauren, who utilized two-colored counters and worked both individually and together to solve the Locker Problem

Analysis:

- Microanalysis (Garcez, 1997): second-by-second transcription and description
- 2x Thematic Analysis (Braun & Clarke, 2006) – *a priori* coding according to Nemirovsky & Ferrara's (2009) multimodality of utterances and Fredericks et al.'s (2004) three domains of engagement.

Process through which Episodes were Selected





	Participant	Verbalization	Other Utterances	Evidential Embodiment	Engagement Type(s)
01:33	Lauren	-	-	-	-
	Rebecca	"Two, four…"	Uses her left hand with fingers spread out to point to the "closed" counters that exist in between the "open" counters.	Gesture, verbalization	Behavioral
01:35	Lauren	-	Extends left hand toward Rebecca and leans back, smiling. *(Figure 5)*	gesture, body poise, facial expression	Affective, Cognitive
	Rebecca	"…six"	-	verbalization	Behavioral
01:37	Lauren	-	Laughs	facial expression, sound production	Affective, Cognitive
	Rebecca	-	Laughs, claps hands once and points toward Lauren *(Figure 6)*	facial expression, sound production, gesture	Affective, Cognitive
1:40	Lauren	"That's pretty cool"	Smiles, laughs, leans over her worksheet	facial expression, sound production, body poise, verbalization	Affective
	Rebecca	-	Laughs, picks up her worksheet with her left hand and brings it in front of her	facial expression, sound production, environment alteration	Affective, Behavioral
01:41	Lauren	-	-	-	-
	Rebecca	"okay, two, four, six"	Uses a spread out hand to count the gaps between the "open" two-colored counters again	Gesture, verbalization	Behavioral
01:45	Lauren	"Dude, wait, that's so cool!"	Looks at Rebecca briefly, and then looks back down at her worksheet	Gaze, verbalization	Affective, Behavioral
	Rebecca	-	-	-	-

Screenshot of Full Microanalysis and Coding for Episode 2

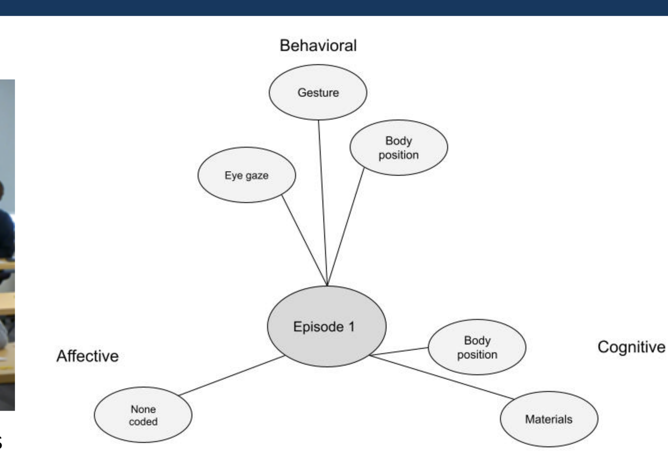
Results

Episode 1: Responsive Resetting

Rebecca interacted with her two-colored counters in direct response to the conversation she heard Lauren and Dr. A having.

Rebecca (right) leaned towards her counters and began resetting them to their original "closed" position when Dr. A (center) prompted Lauren to reconsider the problem.

Rebecca pushed additional counters towards her original line of counters, while Dr. A and Lauren continued discussing Lauren's worksheet.

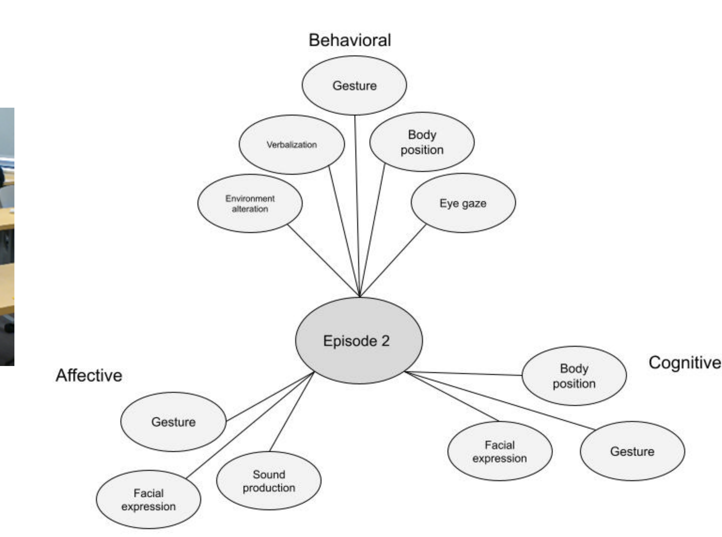


Episode 2: Collaborative Conjecturing

Lauren and Rebecca discovered a pattern in their counters, and expressed excitement when the pattern continued.

Lauren and Rebecca nonverbally and excitedly acknowledged each other, demonstrating a shared understanding of the pattern they both noticed, without ever verbalizing the pattern itself.

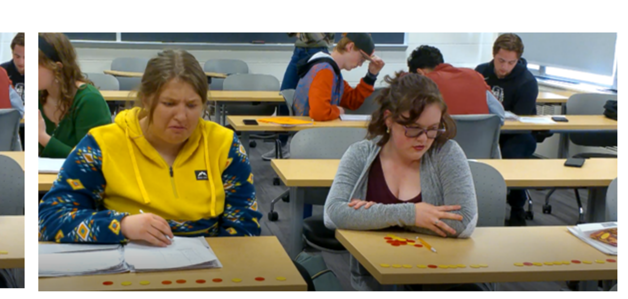
Rebecca laughed, clapped, and pointed to Lauren in a continued display of excitement. This exchange was demonstrative of affect, cognitive, and behavioral engagement by both students.



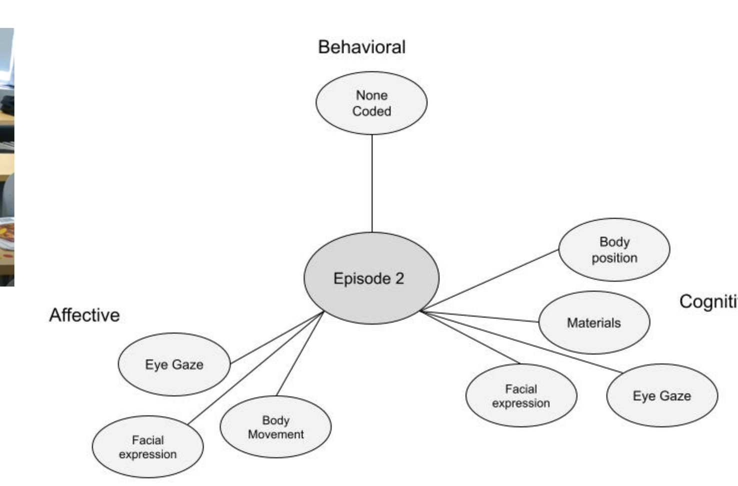
Episode 3: Second-guessing Squares

Lauren and Rebecca both expressed deep confusion when they overheard Dr. A validate a classmate's conjecture, which did not match their materials.

Both students looked towards Dr. A and a fellow classmate, while listening to their discussion. Lauren adopted a confused expression in response to a statement made by Dr. A that seemed contradictory to the pattern discovered in Episode 2.



Lauren shook her head in a continued state of confusion. Rebecca stared intently at the counters in front of her. Both students remained silent, seemingly attempting to reconcile Dr. A's statements with their own discovered pattern.



Findings & Discussion

Embodiment **can** and **does** provide evidence of student engagement in all three domains!

Embodiment provides evidence for students' engagement in ways which…

1. …illuminate engagement which may have gone unnoticed under observational scales which privilege verbalization
   - Episode 1 - Rebecca responds non-verbally to Dr. A's guidance
2. …account for the multimodal nature of both utterances and engagement as constructs (Fredericks et al., 2004; Nemirovsky & Ferrara, 2009)
   - Episode 2 - Rebecca laughs, claps her hands, and points to Lauren, indicating emotional and cognitive engagement
3. …consider the broader classroom context in which the students are engaging with the task (Hodgson et al., 2017; Kahn, 2014; Keith, 2016)
   - Episode 3 - Rebecca and Lauren's cognitive engagement is largely impacted by Anthony's conjecture in the classroom environment

Using embodiment to learn about students' classroom engagement **broadens the definition** of what it means to be a **classroom participator**, and captures engagement that might otherwise go unnoticed. Embodiment has strong potential to help educators notice, understand, and empower non-verbal participation. Further, embodiment offers an additional lens through which researchers may assess engagement.

Future Work

- Triangulating observations with self-assessment data (particularly with relevance to the students' cognitive engagement)
- Examining what a microanalysis of engagement would look like under different teaching paradigms

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