

Seeing Student Engagement in Classroom Video: Affordances of Cognitive and Sociocultural Frameworks

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Abstract: It is a goal of many educators for their students to be engaged in learning. However, there is a lack of agreement about what engagement means and looks like in classroom settings. In this study, we compare the outcomes of two observational measures of student engagement: one grounded in cognitive theory and the other in sociocultural theory. We apply the measures to a small group of 5th-6th grade students engaging in computer supported, collaborative learning (CSCL) embodied science modeling activities. We explore the affordances of each measure for understanding student engagement in small group science work.

Introduction and framing

Engagement is a widely used construct across the educational literature. Although scholars agree that student engagement is important for learning, they vary in terms of both how engagement is defined and how it is measured in classroom settings. Some definitions position engagement as closely related to student motivation (Cents-Boonstra et al., 2021; De Loof et al., 2021; Henrie et al., 2015). Others focus on engagement as students' connection with or attitude towards schooling (DeWitt et al., 2019; Skinner et al., 2009; Sun et al., 2022) or as an interplay between students and their learning environment (Fried & Konza, 2013; Gresalfi & Barab, 2011). In this paper, we define engagement as a multidimensional construct that describes students' participation in learning activities, and explore how a focus on different dimensions changes our understanding of that participation. In particular, we focus on how engagement is studied in CSCL environments.

Researchers have focused on many different dimensions of engagement. Many have taken up Frederick and colleague's (2004) assertion that engagement consists of behavioral, emotional, and cognitive components. Some have added *social* or *socioemotional* engagement, which focuses on groups' interpersonal interactions (Rogat et al., 2022; Sinha et al., 2015). Others have further subdivided cognitive engagement into multiple parts including procedural, conceptual, consequential, and critical engagement as a way of supporting explorations into how learning environments foster different kinds of engagement (Gresalfi, 2015). Finally, scholars have investigated *disciplinary* engagement, and particularly, productive disciplinary engagement (Engle & Conant, 2002). This type of engagement occurs when learners use the discourses and practices of the discipline together during authentic tasks (Cheng et al., 2019; Engle & Conant, 2002; Koretsky et al., 2014). Studies of engagement vary in their focus on one or all of these dimensions, and the extent to which the dimensions are entangled versus separated.

In addition to the variety of ways that engagement has been conceptualized across the literature, there is also variation in its measurement. Studying engagement requires determining the level (collective or individual engagement) and grain size (person oriented or context oriented; Sinatra et al., 2015) at which it is measured. In this study, we are particularly interested in observational measures of engagement. Observational measures of engagement can provide more contextual information than self-report surveys, which tend to be worded generally and therefore, may not provide accounts of contextual factors that influence engagement (Fredericks & McColskey, 2012; Olitsky & Milne, 2012). Ultimately, this work is part of a larger project that we hope can inform how artificial intelligence can automatically identify student engagement based on analysis of classroom data such as videos and student artifacts. To accomplish that, we are exploring how different theoretical perspectives are used to guide observational measurements of engagement.

Researchers' theoretical framework also impacts how they see engagement in a classroom. Cognitive theories often focus on individual learners and their motivation, whereas sociocultural framings of learning and engagement explore the interaction between students and their contexts (Danish & Ma, 2023; Jeong et al., 2014). We seek to explore the ways in which cognitive and sociocultural perspectives shed unique light on understanding student engagement. Our goal is *not* to critique or create a hierarchy of individual measures. Instead, we aim to explore the affordances of each perspective with an eye towards articulating the relationship between defining and measuring

engagement. This type of analysis that takes different lenses on the same data has a history in CSCL that celebrates multivocality in analyzing common datasets to identify synergies, contrasts, and convergences (Suthers et al., 2013).

Building on the dominant theories in CSCL (Jeong et al., 2014), we selected two observational coding schemes based on cognitive and sociocultural theories. For the more cognitive coding scheme we identified Hsiao and colleagues' (2022) observational coding scheme, entitled "Classroom Observation Protocol for Interactive Engagement in STEM (COPIE-STEM)", which is based on the ICAP framework (Chi, 2009; Chi & Wylie, 2014). This framework focuses on learners' cognitive engagement, which is broken into four modes: Interactive, Constructive, Active, and Passive. The dimensions exist on a continuum, with Interactive and Constructive modes categorized by deep processing strategies, and Active and Passive modes categorized by surface processing strategies. *Interactive* engagement refers to interactions between learners that go beyond the learning materials, like elaborating on or challenging classmates' ideas. In *Constructive* engagement, learners engage in generative behaviors, like explaining or inventing, but this can be individual activity; they may not be in dialogue with peers. *Active* engagement refers to manipulation of learning materials without moving beyond them, and *Passive* engagement occurs when learners take in information without obvious activity.

The second coding scheme takes a more sociocultural perspective. Rogat et al. (2022) developed an observational coding scheme from a situated view of engagement. It was designed for use with collaborative groups of students and considers five dimensions of collective engagement: behavioral, socioemotional, collaborative, metacognitive, and disciplinary. *Behavioral* engagement refers to the group's participation on the assigned tasks. *Socioemotional* engagement refers to the quality and climate of the group's interactions. *Collaborative* engagement refers to the balance of participation between group members. *Metacognitive* engagement captures the group's planning and self-regulative strategies, and finally, *Disciplinary* engagement describes the quality of the group's disciplinary and conceptual activity. Based on these two coding schemes, we ask: What are the affordances of each theoretical orientation for understanding student engagement in small group science work?

Methods

Participants and data sources

In order to understand the different ways of operationalizing engagement, we applied the two coding schemes to data from the Generalized Embodied Modeling: Science Through Technology Enhanced Play (GEM-STEP) project (Danish et al., 2022). Participants in the project were 5th and 6th grade students in a class at a private school in the Midwestern United States. The students participated in a series of six lessons focused on energy transfer within aquatic ecosystems (Days 1-3) and garden ecosystems (Days 4-6). The lessons were structured into several two to three minute rounds of embodied activity and debriefs. During the embodied activities, students acted as various agents within the ecosystems (fish, bunnies, worms, energy) while wearing hats with Pozyx tracking sensors on them. Students' movement was then interpreted by the GEM-STEP software and projected on a screen in the front of the room with character avatars representing the students (see Figure 1).

Data sources for this project consisted of classroom video, screen captures of the projected model, and pre and post interviews with the students. In this paper, we analyze data from the last day of the implementation, in which students worked in small groups to plan and test a strategy for modeling decomposition in a healthy garden ecosystem. We selected this day because the small group participation structure provides a clear context for analyzing engagement across multiple dimensions. Students divided themselves into four groups based on their interest in developing a particular strategy. Three groups had consent to be video recorded, and we selected one group of three students and a teacher for analysis based on the clarity of their video data. In this paper, we refer to the three students based on their shirt colors: Blue, Grey, and Red. All three students were White and between 11 and 12 years old. Blue used they/them pronouns, Grey used he/him pronouns, and Red used she/her pronouns.

Figure 1

Students participating in a round of embodied activity (left) and the projected screen (right)



Analysis

Our goal is to explore the affordances of different ways of conceptualizing and operationalizing student engagement as an observable phenomena. As such, we compiled coding schemes that have been utilized as observational measures of engagement in K-12 STEM contexts, and used the two theoretically grounded coding schemes (described above) that we believed might produce interesting contrasts and insights (see Table 1 and 2).

We selected two episodes of group work to code using both coding schemes. In the first episode, three students worked with the classroom teacher to design a model that they thought would portray a healthy ecosystem. In the second episode, the students explained their plan to a researcher, who made edits to the GEM-STEP model as requested, and then the team tried out their plan, with two students using hats to control worms with their bodies, and the third student and the teacher controlling bunnies via iPads. The “planning” episode lasted for seven and a half minutes and the “testing” episode lasted for five minutes.

In originally developing the coding scheme, Hsiao et al. (2022) selected one target student in the class and marked whether each indicator of engagement (interactive, constructive, active, and passive) was present or not for each minute. In order to be able to compare across coding schemes, we applied Hsiao’s coding scheme to each student in the small group, thus producing a view of the group’s engagement based on each student’s participation. Following Rogat et al. (2022), we assigned the engagement of the entire group of students with quality ratings for each of the five dimensions. Behavioral, socioemotional, and collaborative engagement ranged from 1 (low) to 3 (high), while disciplinary engagement ranged from 1 to 4. While they segmented their clips into five-minute segments, we used 2.5 minute segments to be more comparable to Hsiao et al. (2022). Two coders independently applied both coding schemes to the data. Due to its low reliability in Rogat et al. (2022), we did not code metacognitive engagement. The initial percent agreement for each dimension was: Interactive (66.6%), Constructive (83.3%), Active (69.4%), Passive (77.7%), Behavioral (40%), Socioemotional (100%), Collaborative (80%), and Disciplinary (80%). All disagreements were resolved by discussion among the raters until consensus was reached.

Table 1

Abbreviated COPIE-STEM coding scheme adapted from Hsiao et al., 2022

Interactive	Constructive	Active	Passive
Ask classmates questions Answer classmates’ questions Ask teacher questions Answer teacher’s questions	Discussion Operation Tests/tasks Instruct classmates Presentation Ask teacher questions Answer teacher’s questions	Listen and watch Operation Discussion Notetaking Read Instruct classmates Take tests or complete tasks Answer teacher’s questions Ask teacher questions	Listen and watch Notetaking Read

Table 2*Abbreviated engagement rubric adapted from Rogat et al., 2022*

	Behavioral	Socioemotional	Collaborative	Disciplinary
1	Off-task behavior	Negative climate (disrespectful, low cohesion)	Lack of coordination (e.g. separate contributions)	Limited to no content or disciplinary talk
2	Predominately on-task with some off-task	Mixed climate	Mixed coordination or first response taken up with no discussion	Fragmented talk, no elaboration, content as facts/recall
3	Sustained on-task behavior	Positive climate (respectful, cohesive, friendly)	Coordinated actions (group builds on ideas, rejects with rationale)	Brief elaboration or connection of facts
4				Integrates content and practice, intellectual progress

Findings

In our analysis, we sought to understand student engagement from sociocultural and cognitive perspectives so that we could contrast these two perspectives. We begin by presenting the story of engagement that each coding scheme captured (see Figures 2 and 3), and then explore how they complement each other.

Figure 2

Students' engagement from a sociocultural group level (left) and cognitive individual level (right) perspective while planning their modeling strategy in the first episode. Note: Behavioral, Collaborative, and Socioemotional engagement are on a three point scale. Disciplinary engagement can range from 1 to 4.

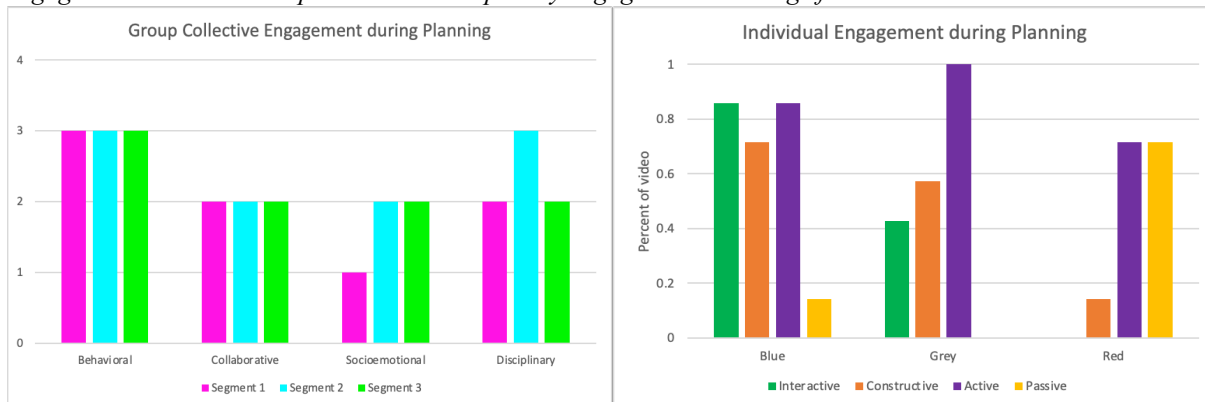
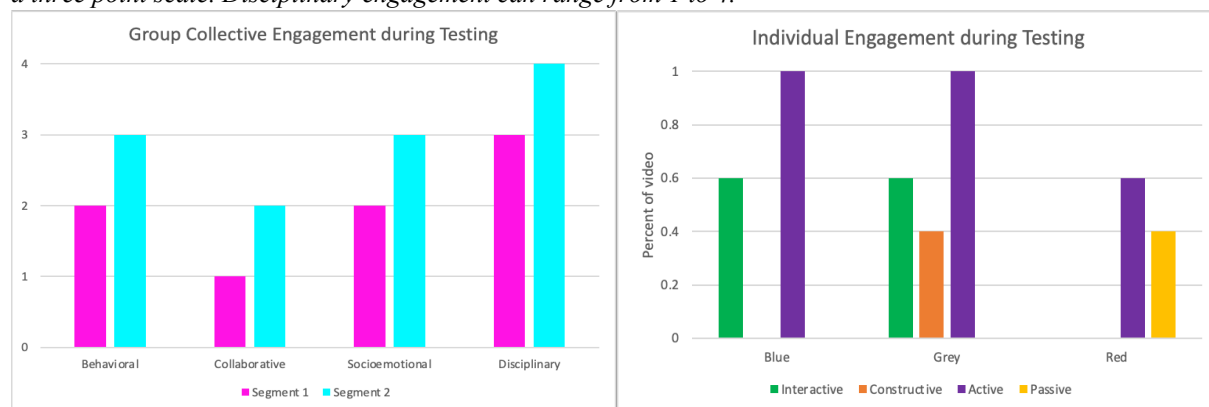


Figure 3

Students' engagement from a sociocultural group level (left) and cognitive individual level (right) perspective while testing their modeling strategy in episode 2. Note: Behavioral, Collaborative, and Socioemotional engagement are on a three point scale. Disciplinary engagement can range from 1 to 4.



Sociocultural Views of Engagement: Group Disciplinary Engagement

Rogat et al.'s (2022) coding scheme measured student engagement at the group level across four dimensions: behavioral, collaborative, socioemotional, and disciplinary. During planning, the small group was characterized by high behavioral engagement, moderate collaborative and disciplinary engagement, and moderate to low socioemotional engagement. During testing, when they participated in embodied modeling, they exhibited high quality behavioral, socioemotional, and disciplinary engagement, and moderate quality collaborative engagement. Throughout the planning and testing sessions, students remained on task the entire time as they discussed how many worms, plants, and bunnies they wanted to include in their model and how they would act in order to keep the ecosystem healthy. However, the groups' lower collaborative and socioemotional quality during planning demonstrate that they struggled to work together. This particular group was working on a "more plants, more bunnies" strategy. Their logic was that more plants would feed more bunnies, who would excrete more waste for the worms to eat and put more nutrients into the soil. While the groups were formed based on interest in strategies, one student got closed out of his preferred group and ended up in this one. Conflict arose between him and another student about how to design their model characterized by the planning segment. This conflict seemed to both provoke and hinder disciplinary engagement, as it required teacher intervention to resolve, which prompted students to explain why their viewpoints were correct and to come to an agreement. When students actually tested their plan in the embodied modeling environment, socioemotional engagement was much higher, perhaps indicating that embodied activities support a positive emotional climate, or that their conflict had been successfully resolved. Moreover, their disciplinary engagement was on an upward trajectory.

Cognitive Views of Engagement: ICAP

Hsaio et al.'s (2022) coding scheme measured individual student cognitive engagement across interactive, constructive, active, and passive dimensions. This coding scheme demonstrated the different roles that students played in the group. During the planning session, Red's engagement was primarily active and passive. She served as the notetaker for the group and rarely verbally contributed. In contrast, Blue and Grey were rarely only passively engaged, and instead took a more active verbal role in the discussions. They both engaged at an interactive level during the planning session, for 85.7 and 42.9 percent of the time, respectively. However, this interactive engagement most often used the codes "answer teacher's questions." There was less evidence that students were asking and answering each other's questions directly. In the embodied "testing" part of the video, this coding scheme was more difficult to apply. Students were most often engaged at an active level as they "completed tasks", but many of the indicators of interactive and constructive engagement did not apply, as the activity was not structured in such a way that asking and answering questions was expected. This raises questions about how cognitive coding schemes can better capture engagement in embodied learning environments.

Integrating the Views

By using both coding schemes in conjunction, we were able to obtain a fuller picture of students' individual and collective engagement. A focus on only individual cognitive engagement missed the negative socioemotional climate and group cohesion that was prevalent when using Rogat et al.'s (2022) socioculturally grounded coding scheme. However, a focus on only group level disciplinary engagement missed how individual students contributed to the group, as was evident in Hsaio et al.'s (2022) cognitively grounded coding scheme. We had a general sense that collaborative engagement was moderate, but did not know which students might have chosen to not participate or were even excluded from participation. In Table 3, we share an excerpt from the planning conversation, in order to ground our findings in students' discourse.

Table 3

The first minute of the planning conversation and its codes. Note that the group level engagement codes refer to the first 2.5 minutes of the clip. / indicate interruptions where the next line of talk began.

Transcript		Sociocultural Engagement	Cognitive Engagement		
Speaker	Talk	Group Level Engagement	Blue's individual engagement	Grey's individual engagement	Red's individual engagement
Blue	I don't care! You're not being a rabbit, Grey!	Behavioral: high	Interactive: answer teacher's questions concerning learning materials	Interactive: ask students questions concerning learning materials	Passive: listening and watching
Grey	Why not?	Collaborative: moderate			
Blue	Cause you're gonna starve us all!	Socioemotional: low			
Blue	Teacher!	Disciplinary: moderate-low			
Teacher	So, why can't he be a rabbit? You want more rabbits, right? Here's another rabbit.				
Blue	He's trying to capitalize/, so we can't eat				
Grey	/Yeah, I'm just gonna eat the plants				
Teacher	Well, isn't that what the more plants are about?				
Blue	Worms can't eat the plants!				
Grey	I'm just gonna eat, and then/				
Teacher	/Pause				
	[Researcher gives instructions for task]				
Teacher	Red, we're in this group.				
Red	I am.				
Teacher	No you're not. You're looking over there. Circle with us.				

In the first minute of this conversation, Blue and Grey were in an argument. Blue was scared that if Grey played a rabbit, he would eat all the plants, leaving none for the other rabbits and causing the ecosystem to die. The teacher's question, "well, isn't that what the more plants are about?," served to prompt students to think about the disciplinary ideas of energy and matter cycles: that when more plants are eaten, the rabbits will excrete more waste, which will provide more food for the worms, and ultimately, more nutrients for the plants. Blue answered the teacher's question, but their answer did not get at this disciplinary content (overall in this first two minute segment, disciplinary engagement was coded as moderate-low). However, by answering the teacher's question concerning learning materials, Blue was also coded for the highest level of cognitive engagement: interactive engagement. The COPIE-STEM Cognitive framework showed that Blue and Grey were interactively and actively engaged and Red was passively engaged, while Rogat et al.'s (2022) coding scheme added information about the quality of that engagement for the overall group. Although students were cognitively engaged, they were not respectful towards each other or willing to hear each other's perspectives.

Implications

In this paper, we explored the affordances of defining and operationalizing engagement in two different ways for understanding students' participation in small group science activities. Student engagement in collaborative embodied activities requires use of an engagement framework that moves beyond traditional forms of engagement, like reading, notetaking, asking, and answering questions. Observational measures seem well designed for understanding engagement in embodied activity but need to also include indicators that go beyond verbal and include gesture, movement, and other kinds of multimodal activity. Like other examples of multivocal analysis, using multiple approaches to analysis here allows for more nuanced understanding. Nonetheless, such analyses are labor intensive and hand coding does not allow the results of such analyses to be actionable in real (or close to real) time. This may be a place where automated analyses may hold promise. In future work, it will be instructive to explore how emerging advances in natural language processing, computer vision, and machine learning can drive multimodal learning analytics that utilize parallel data streams of video (student movement, posture, gesture, and gaze), audio (student speech), and trace data from CSCL learning environments (student problem-solving and intra-environment interaction) to inform models of engagement. In particular, it will be important to investigate how cognitive and sociocultural engagement frameworks based on multimodal learning analytics can help us understand how engagement manifests in classrooms and how CSCL learning environments can realize real time adaptations that most effectively support learner engagement.

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