CHARACTERIZING A MIDDLE SCHOOL STUDENT'S ENGAGEMENT IN A MATHEMATICS CLASS

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This study builds on previous work that investigates the nature of engagement as it occurs 'in the moment' by using the concept of engagement structures (Goldin, Epstein, Schorr and Warner, 2011). In this paper, we report on a young male student, Eric, who called out an answer in response to a question posed by the teacher. He noted that he wanted to impress the others in the class. His solution was immediately challenged by his peers, whereupon, he became defensive and withdrew from the discussion. We attempt to characterize this shift in engagement using the theoretical concept of engagement structures as a way to explain his reactions.

Introduction and Theoretical Framework

The type of engagement that students experience can be important for their mathematical learning (Marks, 2000). Many studies of engagement in mathematics education emphasize students' longer-term attitudes, emotions, dispositions or orientations (Goldin, 2012; Midgley et al., 2000; Patrick, Ryan, & Kaplan, 2007). In such cases, surveys, questionnaires or interviews may determine "how a person typically feels in mathematical situations, and how one person's feelings characteristically differ from another (Goldin, 2012, p.7)". While important, longer term traits may not necessarily capture the 'in-the-moment' nature of student engagement. 'In the moment', as it is used here, refers to the varying patterns of engagement governed by emotions, goals, and social interactions that may occur for minutes, or even seconds at a time as the student works on a mathematical problem (Goldin et al., 2011).

Many factors, such as peer interactions, social contexts, instructional styles, problem types, and technological resources, have been found to impact the 'in the moment' engagement that students experience (Hegadus, 2007; Middleton and Jansen, 2011). In order to better characterize such engagement, Goldin, Epstein, Schorr and Warner (see for example: Epstein et al., 2007; Goldin, Epstein & Schorr, 2007; Schorr, Epstein, Warner & Arias, 2010) conducted a series of classroom based research studies in which they examined student engagement as they worked on solving math problems in a group setting. Their data involved direct and video-based observations, interviews with students about their experiences, and student responses to survey instruments. After careful analysis, several clear patterns emerged which led to the development of a theoretical construct that they refer to as *engagement structures. Engagement structures* are idealized recurring highly affective patterns inferred from observed behaviors and student interviews (see Goldin et al., 2011; Schorr et al., 2010 for a more complete description). These structures consist of a behavioral/affective/social constellation, and include the following interrelated components:

> "(1) a characteristic goal or motivating desire; (2) characteristic patterns of behavior including social interactions oriented toward fulfilling the desire; (3) a characteristic affective pathway experienced by the individual; (4) external expressions of affect; (5) meanings encoded by emotional feelings; (6) meta-affect pertaining to emotional states; (7) characteristic self-talk or inner speech; (8) interactions with systems of beliefs and values; (9) interactions with longer-term traits, characteristics, and orientations, and (10) interactions with characteristic problem-solving strategies and heuristics (Goldin et al., 2011, p.549)".

Fourteen engagement structures have been identified thus far. They range from complete immersion in the solution process, not unlike the concept of "flow" as described by Csikmentmihalyi (1990) to active avoidance of any type of work on the mathematical task. For example, complete immersion in a task can be beneficial at times and exclusionary or inappropriate at others. Similarly, there are occasions when one might want to avoid work on a task when he is feeling sick or upset about something else. These structures are not 'good' or 'bad'. Rather they are contextually dependent. Further, engagement structures do not necessarily operate in isolation. Quite the contrary, they often operate simultaneously or in support of each other, and can shift instantly.

Two structures, which are described below, appear to occur quite often in our research, and are the subject of this paper. Briefly stated, the first, which we call "Look How Smart I Am" occurs when a student has a desire to appear smart, and acts on that desire by, for example, making sure that others know that he knows the answer. The other, which we call "Don't Disrespect Me" occurs when, for one reason or another, a student feels exposed, humiliated, or otherwise disrespected by one or more people (or situations) and perhaps tries to defend an idea or answer to "save face". A more complete description appears below:

> *(1)* "Look How Smart I Am (LHSIA). The student's motivating desire here is to impress others (or, possibly, himself or herself) with the student's mathematical ability, knowledge, intelligence, or genius. Behind this desire may be the need Murray terms achievement: "to increase self-regard by the exercise of talent" (p.164). The desire may be evoked by a potentially admiring audience, or possibly the presence of "rivals" for achieving high regard. The consequent behavior can be competitive, including "showing off" the student's prowess by trying to demonstrate that his or her solution is better than that of others. Emotional satisfaction accompanies the achievement of recognition, if it occurs, that the student's own thinking or achievement is superior (Goldin et al., 2011 p. 553)".

> *(2)* "Don't Disrespect Me (DDM). In this engagement structure, the motivating desire is to meet a perceived challenge or threat to the student's dignity, status, or sense of self-respect and well-being. The likely underlying need is termed by Murray as infravoidance: "to avoid conditions which may lead to belittlement" (p.192). Typically the social context is that of a challenge to the student's expression of a mathematical idea, where the challenge is perceived as belittling or insulting. The

consequent resistance to the challenge – defending oneself – raises the conflict to a level above that of the original task. The need to "save face" then can override the issue of understanding mathematical concepts, for instance in the context of a highly-charged discussion or argument (Goldin et al., 2011 p 553)".

Our research thus far (i.e. Schorr et al., 2010) shows that oftentimes, DDM may occur after an unsuccessful attempt at LHSIA. This study will focus on providing evidence documenting the emergence of these structures in a group of students who are solving mathematical problems using SimCalc Mathworlds® software (Hegedus, 2007). We attempt to address the following research question: How does sharing an idea or solution publicly impact engagement-especially when the answer is incorrect, or perceived to be incorrect? Data for analysis came from three primary sources: videotaped observations, student retrospective stimulated recall interviews and survey data.

Methodology

This research is one part of a larger study. The larger study focused on fifty-five 7th grade students in a predominantly high poverty large urban school district in New Jersey. The students participated in an eight-day teaching implementation taught by a senior graduate student (T/R) from Rutgers University. A large number of students were from minority populations (71% African-American and 18% Hispanic). According to school academic standing and reading level, the students were divided into three classes (low reading level, average reading level and high reading level) by the school principal and 7th grade teachers (Class 1: Low-17 students, Class 2: average- 18 students, Class 3: high-20 students). Observations made prior to the experiment revealed that the students tended to be competitive with each other, often calling out answers and speaking over each other.

Videotaped observational data, pre/post test data and survey data were collected from all classes. The survey (Rutgers University Inventory of Mathematical Engagement (RIME))[1] used in this study was developed by Epstein et al., 2010 in order to measure the presence and strength of the components identified in the various engagement structures. The RIME survey was made up of 63 items measured by a 5-point Likert scale (Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5)). This survey was administered at the end of four of the eight implementation sessions. Four 'focus' students were selected for more in-depth analysis, and they were videotaped during all eight days of implementation. The focus students were all in the average class. These students are referred to by pseudonyms: (Shauna, Sam, Eric and Jen) and were chosen according to criteria deemed to be important for the purpose of this study. The criteria were as follows: demographic information, gender and consent to be interviewed/videotaped. In addition, the criteria included math classroom information obtained from their math teacher regarding: general engagement, persistence when solving math problems, social status, and general math achievement (as determined by state tests). The math teacher's recommendations were gathered during an interview two days prior to implementation. In this study, we focus on Eric, an African American male who, based on the math teacher's classification had the following profile: high social status, low mathematics achievement and generally low engagement with the material.

Several senior researchers and graduate students observed the classes. They met with the T/R (teacher/researcher) each day, immediately after each classroom session, in order to informally discuss what had occurred and characterize hypothesized engagement structures that may have occurred. As a result of these sessions, specific instances were identified for further analysis and for use in the semi-structured retrospective stimulated recall interviews. The interviews occurred eight weeks after implementation with each of the focus students. The interviews, observational notes, video analysis, and RIME results were analyzed for evidence of possible patterns of engagement, and form the data for this research.

In each of the eight implementation sessions, the students worked with simulation software, SimCalc MathWorlds®. SimCalc was chosen because it is a representationally innovative technology software that provides a variety of dynamic, linked representations (including algebraic symbols, graphs, tables, and geometric figures), to simulations, allowing students to reason while directly and dynamically editing and working with representations and corresponding simulated phenomena (Hegedus, 2007). It has also been shown to have the potential to engage students (Schorr and Goldin, 2008). In this particular episode, students worked on: 1) describing what the simulation showed, 2) how to represent what occurred in the simulation by sketching a graph, 3) understanding a time vs. distance graph, and 4) how to find the speed of each runner (Andy and Kim).

Various methods could be used to find the speed of the runner. For example, one common method is the use of the speed formula (speed= distance/time). In the case of Kim, the total distance traveled (50 ft) divided by the time it took Kim to get there (10 seconds) would give you Kim's average speed of 5 ft/s. For Andy's case, the total distance traveled of 50 ft divided by the total time it took Andy to get there (12 seconds) would give you Andy's average speed of 4.2 ft/s. In this paper, we specifically focus on the observational, interview and survey data from Day 3.

Findings and Interpretations

To illustrate patterns of engagement, we share an episode involving a full class discussion led by the T/R. Before this segment, the students had discussed the speed formula (speed= distance/time). Before sketching the graph, the students created a table of values that represented each runner's motion according to the simulation. Once they created the table, they sketched a graph with both runner's time and distance information. Then they used that information to solve for each runner's speed using the formula. In this particular segment, all students were sitting as a group as they discussed the lesson that occurred during the previous session. Eric, the focus of this segment, is seated in the front of the room in close proximity to the T/R.

The T/R asked the students to recall how fast one of the simulated figures, (who is referred to as Andy), is running.

Table 1: Eric's Part 1 of Episode 1

Speaker	Transcript	Description	Interpretive Comments
T/R	So Andy is going how fast? (To class)	At this point, all the students are looking at the T/R. Eric, who had been trying to get the attention of another student, Becca, turns around so as to listen to the T/R.	
Eric	Five, oh four meters per second!	Eric uses his fingers in what appears to be an effort to calculate the answer. He then moves forward, as if to jump out of his seat and calls out the answer (without being asked to by the T/R) before anyone else has a chance to respond. All the while, he looks closely at the T/R. The T/R and the other students appear to be listening to his answer. Eric's answer is actually incorrect, and his mistake is now the subject of the next series of comments.	As Eric yells out the answer, his tone of voice appears to be loud and confident. We infer that he wants the others to hear his answer. He also appears to be closely monitoring the T/R's gaze for signs of affirmation.

We suggest that Eric is attempting to show others that he not only knows the answer, but that he is able to respond before anyone else. Further, his tone of voice is loud, as if he is intent upon having others hear his answer. Such behavior is often associated with the structure that we refer to above as *Look How Smart I Am* (LHSIA). In order to gain insight into Eric's perception of the situation, we share his responses to several relevant RIME questions (see Table 2). His responses were also addressed as part of a semi-structured interview.

Table 2: Eric's responses to items associated with the *Look How Smart I Am* structure

RIME Item:	*Student Response*
I wanted to look smart compared to others in today's math class.	*Agree*
I wanted other students in my class to think I was good at math today.	*Agree*
When I knew the answer today I tried to say it ahead of the other students.	*Agree*
I tried to get the teacher to call on me today when I knew the answer.	*Neutral*
I tried to be one of the first ones to get an answer in doing the math today.	*Agree*

During the interview, Eric was shown a video excerpt of this interaction (and the one that follows in the next section) and was asked: 1) to describe what was going on and 2) to discuss some of the RIME survey responses above. He affirmed that indeed, he did want to appear smart to the other students (and T/R) stating the following: "I wanted to look smart compared to others in class. I said [I] agreed because when I look smart and act smart I feel smart and everybody else would notice how smart I am." The interviewer (the T/R) then asked him the following: "And can you give me an example of when you feel like looking smart?" Eric answered: "Like when I am paying attention and complete my assignment and answer the question first and correctly." Eric's response indicates that he feels smart when he answers the questions first, which seems to confirm the presence of the LHSIA structure.

As the conversation continued, the T/R, in response to Eric's answer, asked the rest of the class: "So Andy was going 4 meters per second?" In table 3, the other students' responses are discussed.

Table 3: Eric's Part 2 of Episode 1

Speaker	Transcript	Description	Interpretive Comments
Sam	No!	Sam yells NO (referring to Eric's answer)! He calls out looking directly at the teacher with a disapproving tone. Then several other students also expressed their disagreement with Eric's answer. Eric then proceeds to look down at Sam and points his finger at him. He also begins to move closer to Sam, touching Sam's backpack.	It appears that Eric is unnerved by this chorus of disagreement. He diverts his eyes from the T/R, toward Sam and the other students.
Eric	Yes it was!	Eric shouts out affirmation of his original answer while still keeping his arm on Sam's chair. He also continues to looks down at Sam as he points his finger at him while waving his hand from side to side. His tone appears to be defensive and louder than when he originally responded. Sam looks ahead toward the T/R.	Eric diverts his eyes from the T/R toward Sam, His facial expressions and arm movements appear to visibly demonstrate his disapproval of Sam's response.
Amir	Yes it was!	Amir appears to be referring to Eric's original answer. He shouts out his answer in a loud tone of voice, while looking at Eric. Eric's chin is down as he continues to look and point his finger at Sam.	Eric now has an ally in Amir Amir's effort to support Eric is unacknowledged by Eric, who continued to look at Sam, the initiator of the disagreement.
Eric	Sam wasn't even here so how could he know.	Eric's tone is defensive. He is still staring at Sam and pointing his finger at him. Sam looks up at Eric and appears to catch his eye.	Eric appears to be annoyed by Sam's challenge to his response as he confronts Sam with the fact that Sam was not even present when the problem was originally discussed. We suggest that this challenge is intended to discredit Sam, and reestablish Eric as having the more reliable answer.
Sam	Oh, when was this?	Sam is still looking up at Eric. Eric continues to stare at Sam.	Sam appears to be responding to Eric's challenge in a more conciliatory manner. Eric continues to stare at Sam in

			what appears to be a defensive manner.
Eric	Yesterday!	Eric responds and continues to look down at Sam. Eric's tone is strained. . Sam looks down at the floor as Eric speaks.	Eric appears to still be upset by Sam's challenge. His tone, eye contact, and general bodily gestures indicate that he appears to be agitated.

In this set of interactions, it appears that Eric reacted defensively when Sam disagreed with him. After publically stating his answer, we suggest that Eric was surprised, and even annoyed by Sam's emphatic (at least initially) rejection of his response. Eric stared at Sam in a way that went beyond just glancing at a peer who was also responding to the teacher's question. We hypothesize that he took Sam's response as a challenge—one that he needed to defend. As can be seen in Line 5, he emphatically stated: "YES it was!" in an angry tone of voice. Our analysis of the situation indicates that when Eric was challenged by Sam's comment, a change in Eric's engagement occurred. Initially, as we noted above, he appeared to be focused on showing others how smart he was. Once he was publically challenged, he felt that he had to defend himself. His tone of voice shifted, and his bodily gestures and gaze indicated that he was agitated. Perhaps he was attempting to 'save face' or avoid the embarrassment of being shown to be wrong in front of the whole class. Eric's response indicating Andy's speed was in fact wrong. As discussed in the Methods section, the correct answer to Andy's average speed is actually 4.2 ft/s. According to further in class discussion, he rounded his answer to the nearest whole number.

As the episode continued, several other students challenged Eric's answer as well. Shaquan, a male student sitting in the back of the room behind Eric raised his hand and waited for the T/R to acknowledge him. When the T/R did, Shaquan stated in a low tone of voice: "the answer is 4.91". As soon as Shaquan answered, Eric repeated his answer from before, again counting using his fingers. Eric stated in a high-pitched tone of voice: "It's 4!" Then in a low tone of voice, while looking down and away from the T/R and the rest of the class: "Well I don't care no more [sic]." Eric's response, at least on the surface, indicated that he was no longer interested in the discussion. However, as the discussion continued, it was clear that was not the case. His comments, however, provided evidence that he wanted the *others* to believe that he no longer cared in this moment, and was not going to further defend his initial response.

Of course, we cannot be precisely sure why he appeared to get angry and defensive in one moment and giving the impression of withdrawing from the discussion in the next. It seemed as if he was invested in impressing others with his knowledge and therefore took Sam's disagreement personally, as a sign of embarrassment or " loss of face", especially since he had made announcement of the answer so public. When several of the other students also expressed disagreement with his response, it is possible that he either doubted the correctness of his answer, or, we believe more likely, wanted to avoid further confrontation or possible embarrassment. It seemed as if he stopped acting on his desire to look smart (as he indicated in his interview). Of course, we cannot know for sure how he thought about this, or what his desires were at this time. However, our evidence, which is presented below, indicates that he did have a need to maintain at least some level of respect. Eric's responses to several relevant RIME questions for DDM appear in Table 4. He was also asked to address several of these responses as part of the interview conducted after the lesson.

Table 4: Eric's responses to items associated with the Don't Disrespect Me (DDM) structure

RIME Item:	*Student Response*
One of my goals today was to make sure no one disrespected me.	*Agree*
I stood up for myself or my ideas today.	*Agree*
I told somebody off or put somebody down in class today.	*Agree*
I wanted to make sure others gave me the respect I deserve today.	*Agree*
I wanted to stand up to someone who disrespected me today.	*Agree*

When he was asked about his response to the item "I wanted to make sure that others give me the respect that I deserved", Eric noted: "Yes (Agree) cause I said I agree because I know I was doing the work correctly and I wanted other people to know how I was doing the work. I wanted to compete." It appears that Eric saw the situation as one in which he needed to 'compete' for possibly the attention of his peers or the T/R, respect, or being viewed as intelligent. Further in the interview, the T/R asked: "So can you give me an example when someone would be very respectful?" Eric stated: "Well, like sometimes when I get 100 on my test people come up to me and say good job. People from other classes would say that it was a good grade and things like that." This response supports the idea that Eric is very invested in what others think about him and/or the accuracy of his answers, which he seems to associate with his knowledge of the mathematics. In his interview, he also states: "Everyone in the class was disagreeing and like we were having an argument." T/R followed up by asking how Eric felt about the argument. Eric responded: "I know I was right but other people were disagreeing with me so I just said oh well I don't care [sic]."

Eric's desire to look smart seemed to be important to him. Sam's disagreement with him publicly made his "looking smart" less likely at best, and possibly humiliating at worst. When Sam announced his disagreement, and when others joined in the chorus of disagreement, Eric began to argue to avoid looking as if he did not know the answer. Not only was his desire to impress others at stake, but he ran the risk of being embarrassed and/or looking less smart.

Discussion/Conclusion

When students share their ideas and solutions publicly in a classroom setting, or more privately when working in groups, they run the risk of being disrespected, humiliated or embarrassed, especially when their answers are perceived to be incorrect. Such was the case of Eric. Eric's situation is not uncommon. We find a similar situation in another classroom as reported in Schorr et al. (2010). In this case, an 8th grade girl named Dana is discussed. Like Eric, she offers an incorrect, or partially correct answer. Also like Eric, another student disagrees publicly with her. She seems to take it personally and argues in a defensive and angry manner.

This type of response, is consistent, as Schorr et al. (2010) states, “with the findings of Dance (2002), Anderson (2000), and Devine, (1996), who note that young people are often hypersensitive to situations in which their emotional safety, status, or wellbeing may be challenged. (p. 3)” Based on Eric’s responses above, it appears that he felt respected when others saw him as smart. Consequently, it would seem that an affront to him, especially one that diminished his appearance of “looking smart” would indeed cause him to feel challenged, and possibly ‘lose face’. It appears as if Eric’s emotional safety or (intellectual) status was, at least potentially, at stake. As a result, Eric responds by first reaffirming his answer, and then by stating that he doesn’t care anymore. We infer from this that Eric is now focused on “saving face”, a behavior often associated with the *Don’t Disrespect Me* structure.

Our analysis reveals how quickly engagement in mathematics can change, especially when a student perceives the situation as having potentially negative (or positive) consequences. It makes sense that when a student is invested in showing others how smart he is, and derives great satisfaction from having others view him as smart, that he would be more vulnerable to feeling disrespected or otherwise threatened (intellectually) when the situation ‘backfires’ on him. This situation may be compounded by the fact that Eric and (Dana) were both perceived by their teachers as having high social status within the class.

It is our hope that as a result of our analysis of these two structures, we are able to provide a language that may be useful to discuss the complexity of classroom interactions similar to these. We also suggest that this analysis underscores the need for teachers to be highly sensitive to the occurrence of such situations so as to avoid possible unintended negative consequences for students.

NOTES

1. This survey was modified since its use in this research. It is currently in the process of being validated.

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