

## **Negotiating Tensions in Collaborations and its Role in Disciplinary Engagement in Science**

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### **Abstract**

While recent reforms in science education envision engaging students in *doing science* as a way to learn science, less is known about how such an engagement can take hold in the classroom. In an effort to address this gap, this study examines the dynamics of students' disciplinary engagement in small groups in a middle school science classroom. Using multimodal discourse analysis, we conducted a comparative case analysis of three groups of students to examine the dynamics of their engagement along conceptual, epistemological, social, and affective dimensions. Through this analysis, our findings highlight tensions that emerge along these dimensions and the ways in which students negotiate these tensions in ways that support or hinder disciplinary engagement.

### **Objectives**

Recent science education reforms emphasize engaging students in collaborative endeavors where students can co-construct scientific knowledge (NGSS, 2013; NRC, 2012). Collaborative group work in science classrooms provides valuable opportunities where students can learn from multiple perspectives, experiences, and beliefs (Bianchini, 1997; Harris Bond & Wing-Chung Ng, 2004; Radinsky, 2000, 2008). But, it has also been shown that simply assigning students to group work does not necessarily achieve those outcomes (Barron, 2003). Collaborative engagement in science not only encompasses active contribution by an individual but also requires acknowledging others in the group as collaborating participants (Barron, 2000). To maximize learning and disciplinary engagement in groups, students need to negotiate a shared understanding of their goals and expectations -- what needs to be done and what resources need to be used to accomplish the task at hand. However, the different understandings and approaches that students employ to complete tasks have the potential to clash against each other, giving rise to tensions. Such tensions can either sustain or hinder disciplinary engagement (Conlin, 2012; Engle & Conant, 2002; Engle et al., 2014). This study examines how three groups of eighth graders navigated the tensions that they experienced during an argumentation activity in a biology classroom. The research questions addressed in this study are:

- What are key conceptual, epistemological, social, and affective tensions that emerge in small groups working on a science problem?
- How do students' negotiations of such tensions support or hinder disciplinary engagement?

### **Theoretical Framework**

In order to engage successfully in collaborative science learning, students need to come to a shared understanding of the conceptual and epistemic goals of their work as well as how they will achieve those goals in a collaborative space (Barron, 2003; Conlin, 2012; Van de Sande & Greeno, 2012). Students might approach their work with different conceptual familiarity (Grooms et al., 2018), different understandings of the nature of that work (e.g.

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sensemaking versus constructing a poster versus doing school work; Jiménez-Aleixandre et al., 2000), and different ideas about the expected social interactions needed to make progress in that work, as well as the roles that each are expected to play and the perceived influence that they have in those roles (Engle et al., 2014). In addition, this work might generate different emotional responses for the students; some might be very curious to “figure out” phenomena while others might just want to finish and move on (Jaber, 2014).

Misalignments along conceptual, epistemological, social, and/or affective dimensions (Ha & Kim, 2020; Radoff, 2017; Shim & Kim, 2018) may lead to tensions that destabilize students’ collaborations. When such tensions emerge, students may either disengage from the group’s work or they may try to negotiate these tensions in order to come to a shared understanding or at least shared outcome. *Conceptual* negotiation is required in the event of multiple, contradicting claims (Oliveira & Sadler, 2008; Sampson & Clark, 2009); *Epistemological* negotiation happens when students have different epistemic goals in mind--such as completing the task for the teacher’s approval or seeking to make sense of a phenomenon (Scherr & Hammer, 2009). *Social* negotiation occurs when students co-construct various social roles and norms and positions of authority and agency in their knowledge construction (Ha & Kim, 2020; Shim & Kim, 2018). Lastly, *affective* negotiation involves attending to each other’s feelings in ways that allow members of the group to respond to one another’s feelings as they arise (Conlin, 2012; Radoff, 2017). In this study, we examine three groups of students engaged in a science task to understand how the tensions in these groups sustained or hindered their disciplinary engagement.

### Methods

This study is part of a larger professional development project geared towards supporting teachers in their attempts to foster student sensemaking about science through talk. The lesson, *Mechanisms of Evolution in Venezuelan Guppies* (Sampson & Schleigh, 2013), occurred in an eighth grade biology honors class across three days and positioned students to explore an existing data set and develop evidence-based claims from those data in response to the guiding question: What causes color variations in Venezuelan Guppies?. The data set was ambiguous in nature--there were multiple variables with marked variation in the data for each. The concepts targeted included natural selection, sexual selection, and the interplay between these mechanisms and how they shape population traits over time and space. Students spent much of their time during the lesson working in small groups to develop their argument and to create a poster to share with their peers.

We present a comparison between three small group discussions that occurred during the argument development phase. The three groups were purposefully selected. The description of the three groups as well as the rationale for their selection are found in Table 1.

### Data Sources

Data drawn upon included video and audio recordings of students’ work in small groups along with classroom artifacts. Drawing on tools from video analysis (Derry et al., 2010), multimodal and behavioral interaction analysis (Jordan & Henderson, 1995; Stivers & Sidnell, 2005), and discourse analysis (Gee, 2004), we analyzed (1) the conceptual, epistemological, social, and affective tensions that emerged during small group work and (2) the nature of student negotiations to resolve those tensions.

## Results

Due to space limitations, here we summarize our key findings regarding the tensions that sustained or hindered disciplinary engagement within the three groups with brief data excerpts to illustrate our claims; in the full paper, we present a more complete analysis. In this analysis, we are referring to tensions as misalignments in students' understandings along the conceptual, epistemological, social, and affective dimensions leading to disagreements in the group.

### *Negotiation of Conceptual Tensions*

The ambiguous nature of the data to be considered in the argumentation activity prompted students to make sense about different aspects of the scientific phenomenon. For all three groups, this initial round of engagement was marked by periods of individuals reading of the task, with students hunched over and focusing on the worksheet and datasets, followed by a discussion among group members where students proposed different explanations of the trends observed in the data. In some groups (for example, group 3) the students were able to come to a shared consensus. However, in other groups (such as group 1), more than one line of reasoning was favored by the group members leading to conceptual tensions in the group. The analysis of the negotiations of conceptual tensions in the three groups is presented in Table 2.

### *Negotiation of Epistemological Tensions*

The negotiations along the epistemological dimension can be examined using the lens of framing (Hammer et.al, 2005; Sandoval, 2005). Epistemological framing is an individual's understanding of "what is going on" in a particular situation (Goffman, 1974; Scherr & Hammer, 2009). Initially, the students in all three groups were aligned epistemologically; they were all interested in figuring out what caused the variation in the coloration of venezuelan guppies. Although initially aligned, we saw a shift in students' epistemological framing in different groups. Shifts in epistemological framing introduced certain tensions in some groups. The analysis of the negotiations of epistemological tensions in the three groups is presented in Table 3.

### *Negotiation of Social Tensions*

In all three groups, at the beginning of the task, all students shared their ideas with each other when they initially explored the data. However, we observed eventual shifts in the social dynamics of the three groups. Students in the different groups adopted distinct social roles. In group 2 and group 3, one or two students took the lead in terms of conceptual contributions while the others donned the roles of listener or scribe. Even with these distinct social roles, we did not observe any social tensions in these two groups. In contrast, we observed social tensions emerge in group 1 around the different roles that the group members aimed to assume at different times. The analysis of the negotiations of these social tensions is presented in Table 4.

### *Negotiation of Affective Tensions*

Affect is very closely intertwined with the other dimensions. In addition to explicit proclamations of frustration and epistemic vexation, we also used the non-verbal cues such as body language, voice intonations, gestures as well as facial expressions to identify feelings and

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emotions that the students were experiencing. During the initial phases of engagement, students in all three groups seemed excited to figure out the phenomenon addressed in the task and appeared to enjoy co-constructing explanations. As the lesson progressed, we observed shifts in student affect. These shifts were closely associated with shifts in their conceptual and epistemological engagement. Since students in groups 2 and 3 reached a conceptual consensus relatively quickly, no affective tensions emerged in those groups. However, affective tensions emerged in group 1 along with tensions that arose from conceptual and epistemological disagreements in the group. The analysis of the negotiations of affective tensions in the three groups is presented in Table 5.

### *Summary*

Our findings highlight various tensions that emerged during the groups' engagement along the conceptual, epistemological, social, and affective dimensions. Our findings also show that for the group's disciplinary engagement to be sustained beyond the initial stage prompted by the task, these tensions needed to be recognized by at least one group member and made public through problematizing questions, expressions of uncertainties, and affective displays. Additionally, these public revelations of tensions needed to be endorsed by another group member to be then negotiated within the group. In the absence of tensions or in the lack of public revelations (group 3) or endorsement of tensions (group 2), disciplinary engagement can be potentially cut-short.

### *Significance*

Collaborative disciplinary engagement can generate tensions that have the potential to sustain or cut-short the engagement. Resolving these tensions is a big part of student engagement in a shared space. The nature of the interactions to reconcile these tensions and conflicts can either sustain or inhibit engagement (Conlin & Scherr, 2018; Engle et al., 2014; Sohr et al., 2018) and so will sustain or inhibit learning. Therefore, there is a need to understand how negotiations along the conceptual, epistemological, social, and affective dimensions influence students' disciplinary engagement. Our comparative case analysis of the multidimensional negotiations in three small groups of eighth grade students adds to the growing body of knowledge that examines students' disciplinary engagement from all four dimensions--conceptual, epistemological, social and affective. It also sheds light on ways in which students can respond to and manage tensions along these dimensions to either sustain or hinder their disciplinary engagement in science classrooms.

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**Table 1.** Description of the three groups and the rationale for their selection

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| <p style="text-align: center;"><b>Group 1 (<i>Sandi, Jessie, Marshal and Desmond</i>)</b></p> <p>This small group consisted of two boys, Desmond and Marshall, and two girls, Sandi and Jessie. The group had a mixed demographic constitution:</p> <ul style="list-style-type: none"><li>● Desmond: Caucasian, Male</li><li>● Marshal: Asian, Male</li><li>● Jessie: African-American, Female</li><li>● Sandi: Caucasian, Female</li></ul> <p><i>Rationale for selection:</i> This group of students was purposely selected for analysis because the group's extended interactions were in contrast with the other students in the classroom who came to a consensus fairly quickly. Furthermore, the students in this group were rarely off-task. Their discussions were focused on mechanistic reasoning about the scientific phenomenon. Rarely did they go off topic and talk about anything other than the task. Additionally, preliminary analysis revealed various tensions in this group despite which their engagement was sustained for about 50 minutes over the period of two days of this three day lesson.</p> |
| <p style="text-align: center;"><b>Group 2 (<i>Ruth, Kendall, Asia, Chad, and Joseph</i>)</b></p> <p>This small group consisted of two boys, Chad and Joseph, and three girls, Ruth, Kendall, and Asia. The group had a mixed demographic constitution:</p> <ul style="list-style-type: none"><li>● Chad: Caucasian, Male</li><li>● Joseph: Caucasian, Male</li><li>● Ruth: Asian, Female</li><li>● Kendall: African-American, Female</li><li>● Asia: African-American, Female</li></ul> <p><i>Rationale for selection:</i> The preliminary analysis revealed that this group had some engagement characteristics that were similar to group 1 and some that were similar to group 3. For example, this group of students came to a consensus fairly quickly, similar to group 3. At the same time, this group also displayed tensions similar to group 1 such as conceptual tensions.</p>   |
| <p style="text-align: center;"><b>Group 3 (<i>Jasmine, Sari, Tan, and Lee</i>)</b></p> <p>This small group consisted of two boys, Tan and Lee, and two girls, Jasmine and Sari. The group had a mixed demographic constitution:</p> <ul style="list-style-type: none"><li>● Lee: Asian, Male</li><li>● Tan: Asian, Male</li><li>● Jasmine: Asian, Female</li><li>● Sari: Asian, Female</li></ul> <p><i>Rationale for selection:</i> This group came to consensus fairly quickly and did not display any tension upon preliminary analysis, for that reason they were selected for comparison to the other groups..</p>  |

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**Table 2.** *Three Groups' Negotiation of Conceptual Tensions*

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**Across all three groups**

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Each of the three groups engaged with the task which presented them with ambiguous data. The concepts targeted included natural selection, sexual selection, and the interplay between these mechanisms and how they shape population traits over time and space. The initial round of engagement was marked by periods of individuals reading of the task, with students hunched over and focusing on the worksheet and datasets, followed by a discussion among group members where students proposed different explanations of the trends observed in the data.

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### **Group 1 (*Sandi, Jessie, Marshal and Desmond*)**

Following initial engagement, Sandi and Desmond had different conceptual lines of reasoning about the data.

- Sandi favored the concept of the turbidity of the water as a potential factor causing trends in the coloration of guppies
- Desmond favored the number of predators.

The different lines of reasoning led to a conceptual tension in the group which was recognized by Sandi who made the tension public using problematizing questions and statements (*“So, you think the haziness of the water affects that but do you think the, uh, especially the predatory fish also affect it? And you think that's affected by the upstream aspect?”*). These questions and statements opened up space for the group to negotiate the tensions by entertaining the different lines of argument and continuing to grapple with the data, debating which one of the factors best explained the trends in coloration (i.e., turbidity, depth, location, and presence of particular types of fish).

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### **Group 2 (*Ruth, Kendall, Asia, Chad, and Joseph*)**

Chad and Joseph entertained several claims related to turbidity, predators, and location of the pool. Chad argued that the number of predators may be associated with the pool location (*“Maybe there are less predators in the shallow and there's more in the deep.”*) Ruth identified an inconsistency in Chad's claim leading to conceptual tensions in the group. She made the tensions public using problematizing statements (*“But pool 4 is deep and has no predators.”*). However, Ruth's problematizing moves were not endorsed by other group members inhibiting engagement.

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### **Group 3 (*Jasmine, Sari, Tan, and Lee*)**

There were no conceptual misalignments observed with this group. Early on, Tan identified turbidity and number of predators as key factors affecting the coloration of Venezuelan Guppies (*“Okay basically, I think that, I think that being a bright male matters less when you're in murkier water because your mating partner won't, likely won't be able to see you anyways”*). The other members of the group readily agreed with his claim and did not present any opposing ideas. Since the discussion was devoid of opposing opinions, it resulted in the group reaching consensus quickly and terminating engagement.

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**Table 3.** *Three Groups' Negotiation of Epistemological Tensions*

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#### **Across all three groups**

Initially, the students in all three groups were aligned epistemologically; they all were interested



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in figuring out (*sensemaking epistemological framing*) what caused the variation in the coloration of venezuelan guppies.

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### **Group 1 (Sandi, Jessie, Marshal and Desmond)**

The initial sensemaking epistemological framing was sustained in this group due to the continuous recognition and endorsement of conceptual tensions by the group members and their negotiations to resolve these tensions. However, upon being reminded of the remaining time, some members shifted their epistemological framing away from sensemaking toward constructing the poster (i.e., doing school) causing epistemological misalignment within the group. Marshall and Jessie wanted to construct the poster (*"Can we, can we at least like start with the rough draft?"*, *"We can like..I mean like..Maybe like, when you're explaining it when we do the presentations, you can mention it but I don't think we have enough time."*) and Sandi and Desmond persisted in their desire to make sense of the phenomenon (*"Why do you think it's because of predators? Of course part of it is predators but like, why would that effect the coloration?"*). Marshall made various bids to persuade Sandi and Desmond to shift their epistemological framing away from sensemaking in the interest of time (*"We don't have to be right, we just have to have a claim and enough evidence to support it"*). This bid, however, was not taken up by Sandi who persevered in her efforts to understand the phenomenon, thereby sustaining the group's sensemaking about the phenomenon at hand.

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### **Group 2 (Ruth, Kendall, Asia, Chad, and Joseph)**

Since there was no endorsement of Ruth's public revelation of conceptual tensions in the group and no negotiations to resolve the conceptual inconsistencies, the students abandoned the initial sensemaking frame and quickly aligned and attained stability in their epistemological framing of the activity as about constructing a poster (*"Our claim is supposed to be why, and our evidence is why, does that make sense? Um, so...the claim would be that levels of turbidity effects the number of bright and drab males that works, that, yeah sure but we should pick one and leave the other one [inaudible] There is turbidity and then there is predators, so, we have our evidence and reasoning we just don't have our claim"*, *"Okay. Um, yeah-This is a nice color. We need to write the question, huh? Oh yeah. Write the word question, wait, wait, how big is this"*).

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### **Group 3 (Jasmine, Sari, Tan, and Lee)**

With the absence of any conceptual challenges to Tan's ideas, the students came to a consensus quickly and transitioned from the initial sensemaking framing and aligned with a stable epistemological framing of constructing a poster (*"Okay so we basically have an outline of why, right?"*, *"You guys wanna start on our piece of papers?"*, *"Lee, you can draw fishes. Give me the pen"*)

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**Table 4.** *Three Groups' Negotiation of Social Tensions*

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### **Across all three groups**

The initial engagement prompted by the task involved students in all the groups sharing their ideas with each other. However, we observed eventual shifts in the social dynamics of the three groups, some of which led to tensions in certain groups.

**Group 1 (Sandi, Jessie, Marshal and Desmond)**

Students in this group took up distinct social roles.

- Sandi positioned herself as the problematizer of the group, prompting the group to think about multiple lines of reasoning, and opening up spaces to include multiple voices.
- Jessie made several attempts to position herself as a collaborative contributor. She showed her intention to accept other students' ideas and discuss them as well as question their explanations; however she often did that in a rather gentle hedging manner (*"So maybe..So maybe this part..this part of the stream where there's three and four, maybe that's specifically used for mating and this is just, that's just land. Cause the drab fish really have no purpose if they don't have the, they don't have the colors. They just a a a food source for the... what's those fish called? Predators"*).
- Desmond initially positioned himself as being the main content authority in the group. This was indicated by the way he presented his ideas as the correct answer, his consistent and continued reiterations of his ideas, and his unwillingness to consider others' arguments.

Desmond ignored Jessie's attempts to contribute by speaking over her or at the same time as she was presenting her ideas. This led to social tensions within the group. Jessie continued to try to socially position herself as a collaborative contributor by attempting to gain access to the conversational floor as well as by using humor (*"Maybe the fish just give up. Fish do that"*) or reminiscing about other moments of vexation that they experienced in the class (*"I feel like every time we get data, we don't get like enough. So, It makes it more stressful than it has to be"*). During Day 2, Jessie became more assertive in positioning herself as a valuable contributor. As Marshall was pushing the group to land on an argument and finish the task (*"It doesn't have to be main effects, just go with it. Let's just go with the broad claim"*), the group almost settled with Sandi's conceptual idea (*"Turbidity affects the coloration of fish"*). However, Jessie at that moment made a pronounced explicit bid to challenge the group's conceptual consensus, pressing them to more strongly support the claim with evidence (*"But can we prove that?...No, literally, she has to prove it"*). This bid was taken up by Sandi which once again reignited the group's engagement.

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**Group 2 (Ruth, Kendall, Asia, Chad, and Joseph)**

This group was characterized by a polarized engagement (Ha & Kim, 2019). Chad and Joseph took the lead in constructing conceptual explanations and sharing ideas in the group on day 1. Ruth was carefully listening to the ideas shared by Chad and Joseph as evidenced by her recognition of conceptual inconsistencies in Chad's explanation. Kendall and Asia did not participate in the discussion on day 1. However on day 2, we noticed that Kendall and Asia were more active, helping the group construct their poster. Asia along with Ruth offered to write the poster (*"I'll write", "I'll go write this down and you guys are gonna have to tell me"*) while Joseph supervised and dictated the contents (*"Cool. Um, both of you. Okay. You're just gonna be both holding the marker and doing it at the same time and I'll supervise. Um, so we're going with the turbidity and predatory fish, right?"*). Even in the presence of these distinct social roles, we did not observe any social tensions in the group.

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**Group 3 (Jasmine, Sari, Tan, and Lee)**

In this group, the lead was taken by Tan who initiated the discussion by contributing his ideas on turbidity and predators (*"Okay, so it kind of makes sense that the murkier water has more*

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*predators so that the prey can't see them coming*”). The other members in the group assumed more of a listening role; they agreed with Tan’s explanation and did not present any opposing views. Similar to group 2, we did not observe any social tensions in this group.

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**Table 5.** *Three Groups’ Negotiation of Affective Tensions*

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### **Across all three groups**

The initial engagement of all the groups with the lesson saw students excited in figuring out the phenomenon addressed in the task and appeared to enjoy co-constructing explanations. As the lesson progressed, we observed shifts in student affect .

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### **Group 1 (*Sandi, Jessie, Marshal and Desmond*)**

As the students in group 1 wrestled to make sense of the ambiguous data, they showed signs of epistemic vexation and frustration (rapid speaking, higher tone, deep sighs, giggling and humor to save face), feelings that kept them engaged in refining their interpretations of the data towards constructing an explanation that resonated with all the members. However, as soon as the teacher reminded the group of the limited remaining time to complete their poster, Marshal’s feelings started to shift as he worried about time pressure to complete the task. Marshal showed signs of his worry and some impatience (as indicated by the increased pitch of his voice) with the group’s continued negotiations to make sense of the data (*“We don't have to be right, we just have to have a claim and enough evidence to support it!”*). This was recognized by Sandi who empathized with Marshal by letting up her epistemic vexation. However, she continued to try and engage others in the group by displays of disappointment as indicated by her putting her head down towards the end.

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### **Group 2 (*Ruth, Kendall, Asia, Chad, and Joseph*) and Group 3 (*Jasmine, Sari, Tan, and Lee*)**

The students in groups 2 and 3 reached a conceptual consensus relatively quickly. We did not observe displays of epistemic affect beyond the initial excitement of “figuring out” the phenomenon prompted by the task. Once the students reached a consensus in their groups, they turned their attention to constructing the CER poster. Much of their animated conversations were about the aesthetics of the poster (*“Oh, we can borrow, we can, you know with these things, we can actually make a drawing!”*, *“That's ugly colors, brown, of all the colors to give us”*).

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