

Understanding students' struggles with collaboration through their views of knowing

Josephine R. Allen (she/her/hers)

Department of Science Education, California State University, Chico, 400 W 1st St, Chico, CA 95929-0535

William Henriquez (he/him/his)

Department of Science Education, California State University, Chico, 400 W 1st St, Chico, CA 95929-0535

Thanh Lê (she/her/hers)

*Department of Physics & Astronomy and Science, Math & Technology Education Program,
Western Washington University, 516 High St, Bellingham, WA, 98225*

Andrew Boudreaux (he/him/his)

*Department of Physics & Astronomy and Science, Math & Technology Education Program,
Western Washington University, 516 High St, Bellingham, WA, 98225*

Carolina Alvarado (she/her/hers)

Department of Science Education, California State University, Chico, 400 W 1st St, Chico, CA 95929-0535

Student-centered learning environments are designed to support collaboration and exploration, directing learning into a collective experience. This case study explores a group of three students, who were highly vocal and determined to understand the activities. They showed attempts to engage in socio-metacognitive patterns, not always achieving it. For example, students explicitly communicated their need to work collaboratively, while another requested to work individually. This qualitative research project collected data from a physics undergraduate course for future k-8 teachers. We center the study on two students who were recorded during their classroom activities, participated in semi-structured follow-up interviews, and submitted reflections regarding their classroom experiences while collaborating in the same group. We analyze students' views of collaboration and reflections to understand their personal epistemology. We present how students' failed attempts at socio-metacognitive patterns can be understood through the differing perspectives of knowing they hold while collaborating as a group.

I. INTRODUCTION

Many student-centered, research-based physics curricula include an instructional strategy referred to as elicit-confront-resolve (ECR) [1, 2]. This strategy elicits common alternative thinking by posing questions known through research to be challenging for most students. Then, it confronts students with inconsistencies that arise from those answers, and finally, leads to students resolving those inconsistencies by building more normative understandings. Confusion often arises as students engage with elicit-confront-resolve activities. While confusion can lead to productive learning discussions, it can also lead to frustration [3].

Multiple studies have shown that, in ECR-based instruction, successful collaboration involves the active negotiation of shared understanding [5, 6]. Socio-metacognition refers to the ways a group monitors and regulates their interactions and collective learning processes. We have adopted the socio-metacognitive framework of Borge *et al.* [4] to gain insight into student engagement and learning during classroom activities that involve explicit confusion. This framework consists of six specific communication patterns surrounding collective information synthesis and knowledge negotiation. In this article, we focus on a single pattern, *Developing Joint Understanding*, in which a collaborative group ensures ideas are understood as intended by speakers by rewording, rephrasing, or asking for clarification.

In addition to the Borge framework for socio-metacognition, we have also drawn on theoretical ideas about students' epistemological beliefs. We have found that examining individuals' ways of knowing can support our understanding of the group interactions that occur during collaborative learning. Baxter-Magolda [7] has developed a framework for *ways of knowing* based on an extensive set of interviews with undergraduate students. In this framework, ways of knowing and patterns within them are socially constructed, and student activation of these patterns is fluid and context dependent. The framework includes four profiles, two of which were relevant for our study.

In the *Absolute Knowing* profile, the role of the learner is to obtain knowledge from the instructor; the role of peers is to share materials and explain what they have learned to each other; the role of the instructor is to communicate knowledge appropriately and ensure that students understand knowledge; and the role of evaluation is to show the instructor what was learned. In this profile overall, knowledge is regarded as certain or absolute.

In contrast, in the *Independent Knowing* profile, the role of the learner is to think for oneself, share views with others, and create one's own perspective; the role of peers is to share views and serve as a source of knowledge; the role of the instructor is to promote independent thinking and the exchange of ideas; and the role of evaluation is to reward independent thinking. In the *Independent Knowing* profile,

knowledge is regarded as uncertain, and each learner has their own beliefs.

In our work we are examining how individual students' ways of knowing affect their negotiation of collective understanding during collaborative learning activities. This short paper addresses two specific research questions: How do students engage in the socio-metacognitive communication pattern of *Developing Joint Understanding* in this learning environment? What views of knowing do students hold while in this learning environment?

II. METHODOLOGY

Our research occurred in a physics course for preservice K-8 teachers at two universities on the West Coast, a Predominantly White Institution and a Hispanic Serving Institution. The course uses NextGen PET [8], a curriculum that includes ECR-based activities. A subset of the authors, who have taught the course many times over more than a decade, identified six lessons that commonly elicit confusion. During the 2021-2022 academic year, we collected video recordings of classroom interactions as well as students' individual written reflections during these lessons. We also conducted individual out-of-class interviews with selected students.

In this article, we develop a qualitative case study of a group of three members: Adam, a White male student, and Angie and Belle, two White female students. This group was highly vocal and engaged in the lessons but struggled to collaborate. We identified moments of confusion from the classroom video and coded transcripts for instances of the *Developing Joint Understanding* communication pattern from the Borge framework [4]. Next, we analyzed transcripts of the interviews with individual students to better understand the individuals' perspectives regarding their group's interactions within this learning environment. Two of the three group members, Adam and Belle, participated in follow-up interviews. The interview questions included: *How would you describe your relationship with science? What role or what impact does uncertainty and confusion have on your learning process in this course? In some lessons in this class, students may not immediately know whether or not their answer for a question is correct, and yet you are still expected to share your ideas. How has this format worked for you?* We used Baxter-Magolda's epistemological framework to identify students' views about knowing in this learning environment [7]. In particular, the framework allows us to assess the extent to which different group members share consistent views about knowing.

Finally, we triangulate our analysis using Belle's and Adam's written reflections about their collaborative work. We reassess both their interactions and engagement in socio-metacognition considering their individual epistemological profiles.

III. RESULTS

We present an overall view of the group engagement in socio-metacognition according to their classroom interactions; we then present data from their follow-up interview to explore their epistemological beliefs. We then present their individual reflections of their experiences in a laboratory session they shared.

A. Socio-metacognitive patterns

We observed Belle attempting to engage in *collective information synthesis* with her peers. Some of these attempts were successful, others were not. For example, after receiving clarification from her partner Angie, Belle notices Adam is confused. Belle offers to clarify the topic, without him explicitly prompting her for support. Noticing and responding to groupmates' confusion is a common behavior implemented by Belle, which aligns with *Developing Joint Understanding*. She has a tendency to request support from her peers when unable to resolve her own confusion.

In contrast, we see Adam with a wider variety of approaches, which align with socio-metacognitive patterns sometimes while looking for individualized progress at other times. For example, the class structure often requires the students to use a whiteboard when presenting information to the class. Adam recognizes Belle's need to create the whiteboard as a group, aligning with *collective information synthesis*, but also vocalizes his need to work independently first. Belle pushes, so Adam changes his approach to merge both individual and collaborative mediums at the same time, walking her through the process while doing it on his own. A different approach we see is him looking to resolve confusion in advance of the activity by reaching out to the instructors of the course rather than engaging in the activity with his peers.

B. Epistemological Assessment

We reviewed the full interview recording for both Adam and Belle, while identifying moments in which they alluded to the way they see learning, knowing, and collaboration in this learning environment. We present quotes from both of them organized by emergent themes from the analysis.

1. Views of science

Belle describes the positive impact of collaboration as a way to engage in science. It alludes to a process that values uncertainty and multiple attempts as part of it.

I have never liked science personally. I'm not the best at science and math, so I've just been standoffish from those subjects. I really like this class so far because it's more of a collaborative class and I feel the main goal or just idea of SCED is that your ideas do matter and your ideas, even if they are wrong, like they're right, because you're trying, and I really like that.

Adam mentions how he used to interpret scientific knowledge as the acquisition of facts and understanding.

I'll be honest, my relationship with science has actually fluctuated a little bit. When I [was] in high school, I started to have ideas-- We have answers for everything and this is why I learned science. I'm learning about cells. I know exactly what A, B and C does and that's how that works.

Adam's view has shifted to an understanding that scientific knowledge is not always absolute or certain; we as scientists are still working to understand scientific truth.

Now I feel I've actually surpassed that where I'm to this point where it's like, this is what I'm being taught, this is what the leading experts know, but there is still some convolutedness of this information up here. Even the top of the line scientists are still asking questions. [Interviewer interrupts saying we know a small amount]. Exactly. Having to understand that the world around you has an explanation, but also doesn't.

Belle has a strong sense of science as a process while we see Adam moving from a set of facts to a process.

2. Engaging in Learning

Belle values collaboration as a key component of learning over individual engagement, showing frustration at being rushed through the process.

A lot of [group members] would just rush through the activities as if it was a race or that they didn't even want to learn the material, that they just wanted to get this done. [...] It felt like a competition to get something done when that's not what learning is. Learning is collaborative and learning is something that you should enjoy.

Adam describes the value of sitting in and working through your confusion during the learning process.

I think to have that initial, pondering questioning phase is really important because it opens your mind up to questioning, how does this work, without the answer, how does this work?

In contrast, 20 minutes later, he describes his own discomfort with this kind of engagement, preferring to know with certainty.

I get into this area where I'm like, am I right or am I wrong? The way I want to learn, the way I choose to push to learn. I want to learn things; I want to know things. Even though the culture of the class is like building blocks.

Belle values engaging with the process of learning, Adam also recognizes its value. In contrast, Adam also mentions his need to access knowledge with certainty at times.

3. The Role of Confusion or Uncertainty

Belle places a high value on working through confusion as part of the learning process to the point of describing it as a fun experience.

I think [uncertainty or confusion] makes me want to learn even more, because then that confusion will eventually lead into learning, which is really fun to - get, I guess. [...] The point is to question and to have that confusion, and then it's what you do with that confusion and how you ask questions is really valuable.

Adam has discomfort in not knowing, preferring to skip the uncertainty in order to reach a resolution.

I'm a very hyper-fixated person. [...] Because in 90% of this course, we get presented with physical problems [...] We don't necessarily know the answer to them right away, and so my hyper fixed mind is like, "Okay. I want to get to the bottom of this, as fast as possible. Because I want to know this." It bothers me when I don't understand how things work.

We notice how Belle values confusion as part of the learning process while Adam is “bothered” by it.

4. The Role of Peers

Belle relies on subtle cues for her group members to notice and respond appropriately to receive help.

I feel like I [ask for help in a really specific way] if I'm really not getting it, but if it's-- I usually just do cues because I-- This is weird, but I think that people can tell if I'm struggling in a weird way. I'm like, "Okay, so..." and then someone would continue my sentence or help me to explain it a little bit deeper.

In contrast, Adam is not focused on monitoring and interpreting his groupmates' social cues for help, but on uncovering the correct answer.

My entire focus, and you can see that, is on understanding. It's like okay, what is truth? What is truth? That's wrong in the sense of what we're supposed to be doing. We're supposed to be learning about how other people learn, I guess, which is on me, completely. Because it's like, I'm not focusing on my other classmates, I'm focusing on the material, not the metacognitive approaches.

This shows a difference in the role of peers for each of them. For Belle, peers are a key component in her learning, while Adam's process does not depend on others.

5. Leveraging Knowledge in a Group

Belle, who has not taken a physics course before, believes that participants do not need to have a full conceptual understanding to be a valuable participant.

One time I raised my hand, and I got the answer wrong, like WRONG. Then, Jenn was like, "This is why I never raise my hand." I was like, "Ohh." That's

like what we've just been taught our whole lives, is that your answer needs to be right, and I'm like, no, it doesn't. It can be wrong, and that's how you learn.

Adam shows how transitioning from an individual to a group pace was a difficult shift for him, from his previous physics classes. Also, there is an assumption that there is an expected level of preliminary knowledge gained from prior schooling which also regulates their interactions.

It was a big learning curve for me, [having] to slow down and really be okay with taking the pace of my people at the table. Definitely a hard thing to learn and definitely something I didn't get from the very beginning [...] I just assumed people were as educated as I was, which was definitely a mistake.

Belle considers initial ideas are useful to build an understanding, disregarding its accuracy. Adam is now aware of the different levels of physics knowledge people come into class with and sees it as a challenge to collaborate.

C. Individual written reflection on their experiences

We compare the individual written reflections from Belle and Adam. After collaborating in a lesson on energy transference models, students had some prompts to reflect on their experience. This is done individually after class.

The course encourages students to use whiteboards to share their ideas and results of certain sections of the work with the rest of the group. Belle shared “I found an understanding of [the topic] after doing most of the work and working through it on the whiteboard,” noticing this tool as a source of learning. Adam mentioned the use of whiteboards as a source to foment collaboration rather than understanding, “Whenever we completed a whiteboard we almost always included everyone as it was a very interactive part of the activity.”

The course is organized through students working in small groups during the lessons. We see how Belle's interaction with a group gets compromised when it is seen as a competition rather than a collaboration:

With this past group that I have had it has been frustrating. Mainly because this class is a very collaborative class, my group has treated most of our work as a competition to be completed.

In contrast, when Adam is discussing the group, he focuses on the different paces the individuals have during the activity, which is not problematized:

When we were completing the activities, oftentimes some of us would fly ahead and complete more pages much more quickly than others in the group.

They both reflected on their group collaboration. Belle perceived it as frustrating given the lack of engagement in the process of understanding the phenomena:

While I make sure everyone is on the same page, most of my group seems as if they want to get the work done and checked off while I want to understand the work. As much as I want to get the work done too, I also want

to make sure I comprehend it and in my group right now it just seems as if they don't want to understand it, they want to get the points and move on.

In contrast, Adam perceived it as positive. He considered that each student had the space to contribute their ideas and were mindful of the other students' learning process:

I think some of the most important aspects that helped facilitate strong group interactions was positive and respectful communication. This means allowing others to comfortably share their ideas, respecting the voice of others, and being mindful of your perspective on a situation as well as others.

Through these prompts, responded individually, we can observe how Belle's focus was on the collaboration not supporting their understanding, while Adam's focus was the ways of communicating rather than their collective understanding.

IV. DISCUSSION

We observe that Belle's engagement with this group is very consistent with the information shared during the interview and reflection. She considers learning to be accomplished through the process of collaboration between peers, who are seen as a resource in the learning process. There is no need for certainty in the learning process since she considers the exchange of opinions, given that each might have their own perspective, valuable. Therefore, we can see how she could be considered an Independent Knower in this context.

In contrast, we see a variety of ways in which Adam engages with the team, which is also reflected in his contrasting statements during the interview. On one hand, he states that knowledge is uncertain, even to the greatest scientists; he values allowing students to work through their confusion on their own and synthesize their own understanding. This aligns with him prioritizing Belle's need for collaboration during the lesson even when he had requested time to work on it individually first. He recognizes that working through uncertainty is valuable for the learning process. These statements show Adam aligning with the views of an Independent Knower.

However, we also see Adam holding a different view of knowing. During the interview, he refers to his past as believing science was more align with a set of facts, to which he had changed. Nevertheless, he mentions being uncomfortable when knowledge is unknown, or understanding has not been attained. He states that it bothers him not understanding how things work, he wants to get to the answer or an explanation as quickly as possible. These statements align with him often requesting help from the instructors of the class, rather than seeing his peers as a resource. He usually engages in collaboration after attaining understanding as an individ-

ual. He recognizes a different pace in his learning progression between him and the rest of the tablemates, without perceiving it as a problem. Therefore, Adam also aligns with an Absolute Knower in this same context simultaneously.

The learning environment in which this class was set up requires students to collaborate through the experimental exploration of conceptual understanding. It pushes students to record and explore their initial ideas, confront them into a set of data collection, so they can come up with a supported view of the phenomena. Therefore, it fosters students engaging in socio-metacognitive patterns, especially *Collective information synthesis*. It provides the means for students to look for collective, rather than individual, understanding. Looking at this environment, we can see how it supports the success of Independent Knowers, as it views the nature of knowledge as uncertain and positions peers as a resource.

We believe that the differentiation between their epistemologies contributes to the group's instances of unproductive collaboration. While Adam navigates this learning environment as an Absolute Knower in some instances and as an Independent Knower in others, it can pose challenges to a student who is consistently engaging as an Independent Knower. A collaboration between students that values the answer (Absolute Knower) more than the process (Independent Knower) can create a tension of goals during collaboration. When these differing perspectives are expected to develop a collective understanding through collaboration, differing needs will need to be met. During the classroom experience, both Adam and Belle are explicit about what they need from the other to succeed - Belle, collaboration, and Adam, in addition to moments of collaboration, individual thinking time. Because these epistemologies fundamentally differ from one another, there is an expectation that it will be challenging for the two students to adequately support the others' learning needs while also supporting their own.

IV. CONCLUSIONS

In a learning environment that aligns with socio-metacognition, exploring students' epistemologies can help us analyze students' interactions. Increasing student awareness of their own epistemology could benefit their ability to engage in productive group collaboration. Students' awareness and reflection on their thinking about learning could impact their future teaching practice. Particularly, noticing how the current science standards include practices around collaboration and communication, we consider it of high relevance to foster this reflection process in pre-service teacher populations.

ACKNOWLEDGMENTS

This project was funded through the National Science Foundation Grant DUE-2021547 and DUE-2021307.

- [1] L.C. McDermott, American Journal of Physics 69, no. 11, p. 1127-1137 (2011).
- [2] L.C. McDermott and E.F. Redish, American Journal of Physics, 67, p. 755-767 (1999).
- [3] S. D'Mello, B. Lehman, R. Pekrun and A. Graesser, Learning and Instruction 22, no. 2, p. 145-157 (2014).
- [4] M. Borge and B. White, Cognition and Instruction 34, no. 2, p. 323-360 (2016).
- [5] Iiskala, M. Vauras, E. Lehtinen and P. Salonen, Learning and instruction 21, no. 3, p. 379-393 (2011).
- [6] S. Volet, M. Summers and J. Thurman, Learning and Instruction 19, no. 2, p. 128-143 (2009).
- [7] M. Baxter-Magolda, *Knowing and Reasoning in College: Gender-Related Patterns in Students' Intellectual Development* (Jossey-Bass, San Francisco, 1992).
- [8] <https://activatelearning.com/next-generation-pet/> Retrieved 5/22/2023.