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"The Answer is Your Thinking…:" One Teacher's Role in Helping Students in Navigating their Epistemic Vexation

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Abstract: Current understandings of science learning revolve around students' developing the ability to use science concepts and practices to "figure out" aspects of the natural world. One emerging area of focus in this new vision of learning is the emotional work required in students' participation science sense making. This research focuses on how one teacher supports student reframing of moments of epistemic vexation. After reviewing classroom video, and interviews, three themes emerged: (1) Productive meta-affect is more likely to occur when students understand why the teacher allows for failure to connect ideas or understand scientific concepts, (2) Without explicit attention from the teacher during moments of epistemic vexation, students can disengage from sense-making and (3) When the teacher does not adequately attend to students' epistemic vexation, students can build solidarity and reach out to each other for emotional support in developing meta-affect.

Introduction

Science Education has transitioned from a portrait of science learning as one driven by the recognition of "facts" to that of science proficiency--in which students are to gain the ability to engage in sense-making about the natural world (National Research Council [NRC, 2012])- learning to "figure things out" (Passmore, 2014). An emphasis on authentically engaging in the discipline of science asks students to share, discuss, and refine thinking about scientific phenomena in a classroom community (Bamberger & Davis, 2013; Berland & Reiser, 2009; Manz & Suarez, 2018; McNeill et al., 2006).

Many aspects of this disciplinary engagement have been widely studied and continue to be a focus of ongoing investigation. One emerging area of focus is that of the emotional work involved in science sense-making. Davidson, Jaber and Southerland (2020) and others (Arango-Muñoz, 2014; Jaber & Hammer, 2016a, 2016b) argue that epistemic affect-- learning how to *feel* as scientists do when engaged in their work-- should be recognized as a central component of meaningful disciplinary engagement in science. Epistemic affect includes "the emotional responses, feelings, and dispositions that emerge as one participates in the construction of knowledge through figuring things out about the natural world" (Davidson et al., 2020, p. 1009). Additionally, meta-affect (feeling about feelings), also plays an integral role in construction of knowledge and beliefs (Goldin, 2002). There is a growing recognition that these emotions are not just unnecessary by-products of scientific work, but rather they are part-and-parcel of doing science, as these emotions are part of what "instigates and stabilizes disciplinary engagement" in scientific pursuits (Jaber & Hammer, 2016b, p. 189). From this position, epistemic affect is recognized as an essential aspect of scientific research and thus needs to be considered as students are learning to engage in science practices (Davidson et al., 2020; Jaber & Hammer, 2016a). The work presented here is an extension of this line of inquiry, as we examine a teacher's response to his students' epistemic vexations.

Research Question

While this is an emerging area of inquiry, much work remains in terms of understanding how teachers can support their students as they learn to manage the emotions inherent in disciplinary engagement. Toward those ends, this work provides a description of a teacher's efforts in supporting his students in navigating these emotions. The question at the center of this research is: What is the teacher's role helping students navigate moments of epistemic vexation, so students maintain their engagement in sensemaking?

Study Design

Data for this study comes from a larger four-year professional development (PD) project focused on supporting teachers in their work to foster student sense-making through productive science talk (Southerland et al., 2017). Danny was our focal teacher, was intentionally selected because of (1) his teaching approach that focuses on helping students to be agents of their own learning, (2) his focus on students' reasoning and deepening of this reasoning in his course, and (3) his long-term participation in the PD. For this study we selected to follow his

Advanced Placement (AP) chemistry classes in year one and four of the PD. A diverse group of students' interviews and classroom observations were coded to support initial themes.

Data sources for this study include classroom video and audio recordings, teacher interviews, and student interviews. After analyzing these different data sets in terms of their alignment around epistemic vexations and the ways in which Danny's efforts allowed students to reframe moments of epistemic vexation, the research team conducted final interview to capture Danny's perspective of students' epistemic vexation boundaries.

We employed a constructivist grounded theory approach (Charmaz, 2017) to analyze the data, where patterns were identified in both Danny and his students' perceptions of his teaching. The first author adapted the coding scheme from Radoff et al. (2019) to identify common themes in the student interviews, as well as the themes presented in Danny's final interview. The second author drew out common trends in Danny's four post lesson interviews and two end of year interviews to identify how he framed student emotions when teaching.

Findings

Theme 1: Productive meta-affect is more likely to occur when students understand why the teacher allows for failure to connect ideas or understand scientific concepts.

Danny prioritizes giving his students experiences where they have the responsibility to determine the meaning to be derived from their experience, which may lead to students experiencing emotions similar to those of scientists and create space for student agency of their own learning. Students are given opportunity early on in the course to share their thinking as a way to build resiliency as they reason through their ideas. Danny explained how he set up expectations to support agency and resiliency in his course:

> [L]ike setting the expectation, that regardless of your comfortability level, like you are going to share at some point, but at least having them start off with the experience of sharing in the lower stakes setting of a group of four people is a place to start off, where they don't instantly feel like the entire class is watching and judging…

This goal of providing students experiences, to "be like a scientist", which was necessary for their own sense-making, was not unnoticed by Danny's students. As Candice stated in her end of year interview:

> It definitely felt more like we were the scientists, not the students, I guess, let's put it that way. It felt like we were, we were scientists and not like we were making a discovery, although it was already proven, but like, still felt a lot more interesting.

However, students did not understand why Danny would not answer their questions or give them closure on concepts, and in turn students experienced frustration that in some students became anger. In Candice's understanding she continued:

> You would ask him like, "Well why does this happen?" He'll be like, "I don't know, figure it out" and you're like, "I need help! I am 16 years old! Okay? I am not a chemist. I don't know. Please help!" Um, the [task] just frustrating cause I never got closure on anything...With this one [chemical equilibrium investigation], we weren't getting it so he was frustrated with us and we were mad at him and it was just a really toxic environment because everyone was mad at everyone."

Throughout the year Danny continually pushed his students to rely on their own ideas, and toward deeper sense-making. At times he kept students productively engaged in that effort through careful questions, and in other times those questions push students past their vexation boundaries, causing them to become frustrated and disengage in sensemaking.

Themes 2 & 3: When the teacher does not reframe moments of epistemic vexation, (1) students will disengage from sense-making or (2) students will build solidarity and reach out to each other for emotional support in developing productive meta-affect.

Danny sees questioning as a way to "get [students] onto that train of thought", as he focuses students on the sensemaking portion of a lesson as students grapple with their explanations. Wanting students to "at least attempt to grapple" with ideas as he addresses questions to entire groups but expects students to engage, even if at the very least they are passively engaging. Danny states:

> So, usually I always focus on the "why". My kids will tell you that "Why?" is my favorite question. And if they can't answer that, I'm not gonna let them not, so I'll just keep pressing them until eventually they tell me what they know.

It is evident that Danny's students are also aware of his consistent presses as he questions and probes their thinking. Hannah stated, "Even whenever he's teaching, if someone has a question, he asks them like, okay, well how do you think this will happen?". Likewise, Emily had mentioned in her end of year interview, "He would never give us a direct answer and even when I had like come to him and ask him a specific question, he would make me work myself to the answer."

In one moment during implementation of a lesson, Danny asks one small group member, Kyle, to make a relationship about the elements on the periodic table. While Kyle appears to be confused on the relationship in the periodic table (shuffling papers in his hands while staring at Danny without saying anything), Ryan, another group member, speaks up to address Danny's question and further the train of thought that is being built. Students look to Danny for answers, and while he realizes this he does not comply. Instead, Danny uses the building of ideas within the group to help students make sense of their own observations. Danny knows students become frustrated by his constant questioning instead of answers, as students look to him as an authority in the classroom. He stated in one of his end of year interviews:

> [Students] are probably going to be frustrated. This is what we're going to do in this class. I would advise you to not try to read answers off of my face, because I typically don't change my tonality, and I don't change how my face looks. So just trying to guess if you're right or wrong by looking at my facial reaction, that's not gonna go well for you.

In another classroom moment during a whole class discussion with a student named Carol, Danny asks "Why was green the one with the highest energy?" This question is the turn in conversations that began to lead Carol away from the idea she was initially trying to express. The frustration that Carol exhibits (identified by her flushed face nervous tone to her voice and putting her head in her hands) is observed by others in the classroom This moment provides a common experience which later helped build solidarity amongst students. During student interviews, students were asked to watch this moment and talk through their feelings and recall what was happening with a researcher. Hannah speaks about solidarity in her interview, "During that lesson, I didn't feel as bad cause I think I felt like, okay, like majority of the class isn't getting it either. So it's not just me." This solidarity helped students be more empathetic with each other's sense-making which in turn led them to emotionally supporting each other when they experienced feelings of frustration or confusion. Students expressed their gratitude for their peers throughout the interviews.

> But I always had partners so we could talk about it together. So, it wasn't just me like figuring out the answers. -Emily

> Yeah, well I think it's like the whole class having that discussion, it just makes it a lot easier because it's not just you and even if it was just you and your group, you know sometimes you and your group really might not know the answer. Some when it is the whole class. At least one person's bound to get it right or like at least one person at least somewhat understands and can help explain it. -Hannah

While student support and solidarity can build a sense of community, this solidarity is not always enough. In the moment with Carol and Danny, the lack of substantial guidance from the teacher when a student so obviously has been pushed beyond her vexation boundary can have a lasting impact. Rose stated in her end of year interview, "Yeah, I think like, I don't know, I don't know like [Carol] especially like towards the end of the year, like stopped talking as much as she used to."

Contributions

This work offers insight into the case of one teacher and his students' perspectives on moments when students are tittering at their epistemic vexation boundaries. Danny views epistemic vexation as a necessary part of

student sensemaking. For sake of disciplinary connections, Danny forgoes attention to students' emotions and his own in order to make space for empirically driven sensemaking. This does not mean that Danny is not aware of these emotions but given his teaching goals he chooses to not forefront in science learning for his students.

While this is only one teacher and his role in helping students navigate epistemic vexations, it speaks to a need to attune teachers to the need to recognize and find techniques to help students navigate students' epistemic vexations. If we are to successfully engage students in the thinking of the discipline, teachers will need to learn to recognize, value, and support students' emotions involved their wrestling with uncertainties (Jaber et al., 2022; Manz, 2015; Manz & Suarez, 2018)

References

Anderson, E., Carleton, N., Diefenbach, M., & Han, P. (2019). The relationship between uncertainty and affect. *Frontiers in Psychology, 10*: 2504.

Arango, S. (2014). The nature of epistemic feelings. *Philosophical Psychology, 27(2),* 1-19.

Bamberger, Y. &. Davis, E. (2013). Middle-school science students' scientific modelling performances across content areas and within a learning progression. *International Journal of Science Education, 35*(2,) 213-238, DOI: 10.1080/09500693.2011.624133

Berland, L., & Reiser, B. (2009). Making sense of argumentation and explanation. *Science Education, 93(1),* 26-55.

Charmaz, K. (2017). The power of constructivist grounded theory of critical inquiry. *Qualitative Inquiry,* 23(1), 34-45.

Davidson, S. G., Jaber, L. Z., & Southerland, S. A. (2020). Emotions in the doing of science: Exploring epistemic affect in elementary teachers' science research experiences. *Science Education, 104*(6), 1008-1040.

Jaber, L. (2021). "He got a glimpse of the joys of understanding": The role of epistemic empathy in teacher learning. *Journal of the Learning Sciences.* https://doi.org/10.1080/10508406.2021.1936534

Jaber, L. Z., & Hammer, D. (2016a). Engaging in science: a feeling for the discipline. *Journal of the Learning Sciences, 25*(2), 156-202.

Jaber, L. Z., & Hammer, D. (2016b). Learning to feel like a scientist. *Science Education, 100*(2), 189-220.

Jaber, L. Z., Dini, V., & Hammer, D. (2022). "Well that's how the kids feel!"—Epistemic empathy as a driver of responsive teaching. *Journal of Research in Science Teaching*, *59*(2), 223-251. https://doi.org/10.1002/tea.21726

Manz, E. (2015). Resistance and the development of scientific practice: designing the mangle into science instruction. *Cognition and Instruction, 33(*2), 89–124.

Manz, E. & Suarez, E. (2018). Supporting teachers to negotiate uncertainty for science, students, and teaching. *Science Education, 102*(4), 771-795.

McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *The Journal of the Learning Sciences, 15*(2), 153–191. doi:10.1207/s15327809jls1502_

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

Passmore, C. (2014, November 10). Implementing the Next Generation ScienceStandards: How your class is framed is as important as what you do [web log post]. Retrieved from http://nstacommunities.org/blog/2014/11/10/implementing-the-next-generation-science- standards-how-your-classroom-is-framed-is-as-important-as-what-you-do-in-it/

Radoff, J., Jaber, L., Hammer, D. (2019). "It's scary but it's also exciting": Evidence of meta- affective learning in science. *Cognition and Instruction, 37*(1), 73-92. doi: 10.1080/07370008.2018.1539737

Southerland, S.A. , Granger, E., Jaber, L., Tekkumru-Kisa, M., & Bevis, T.. *Learning through Collaborative Design (LCD): Professional Development to Foster Productive Epistemic Discourse in Science.* National Science Foundation, DRL #1720587.

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