# STEM INSTRUCTORS' NOTICING AND RESPONDING TO STUDENT THINKING

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*Effective instruction is enabled by an instructor's attention to student thinking and their ability to respond. Further, instruction that is student-thinking-centered can lead to increased conceptual understandings and improved learning experiences for students. Despite this evidence, there is limited research about college instructors' noticing of student thinking. The purpose of this study is to better understand what college STEM faculty notice, and how this enables or constrains their ability to respond to student thinking. STEM faculty, who taught introductory courses, were filmed and interviewed using a semi-structured stimulated recall protocol. Transcripts were analyzed using open coding and thematic analysis. Initial results highlight differences in how faculty elicit student thinking, what is noticed about student understanding, and how this impacts the degree to which faculty can be responsive to student thinking.*

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There have been calls for increased attention to the teaching of introductory undergraduate science, technology, engineering, and mathematics (STEM) courses and professional development (PD) for those who teach these courses, in an effort to improve enrollment and retention rates in STEM disciplines (Bok, 2013; Holdren & Lander, 2012). Effective instruction is enabled by an instructor's attention to student thinking (e.g., Erickson, 2011). Further, instruction that leverages student thinking can lead to increased conceptual understanding and more positive learning experiences for students (Carpenter et al., 1989; Thornton, 2006). The purpose of this study is to investigate what college STEM instructors notice about student thinking, and the ways in which instructors respond as they make instructional decisions.

## Research on Professional Noticing

The noticing required for effective teaching is specialized and goes beyond simply being observant (Ball, 2011). Most scholars agree that it consists of attending to and making sense of particular events during instruction (Sherin, Jacobs, & Philipp, 2011). Jacobs, Lamb, and Philipp (2010) narrow this scope and describe professional noticing as three interrelated skills: attending, interpreting, and deciding how to respond to students' mathematical strategies.

Despite the growing amount of research investigating teacher noticing at the K-12 level, there is little known about what this construct looks like at the college level. Amador's (2014) work investigating future mathematics teacher educators' noticing, one of the few studies at the post-secondary level, found no significant changes in participants' noticing over the short term of the study, but suggested that teachers continued engagement with noticing and reflecting could promote professional growth in this area. This is also supported by evidence that instructors can develop their ability to notice through PD (e.g., van Es & Sherin, 2002).

In order to support college STEM instructors' ability to notice and respond to student thinking, it is first essential to gain a better understanding of what instructors notice, and how they respond through instructional decisions that leverage student thinking. In this paper, I investigate the following research questions: (1) What do college STEM instructors notice about their students' understanding? (2) In what ways are college STEM instructors responsive to their students' understanding (i.e. use student thinking to inform instructional decisions)?

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I focus this study broadly on college STEM instructors since little is known about what instructors notice at the post-secondary level, and how this interacts with how they respond to student thinking. It is worth noting that when investigating teacher noticing at the K-12 level, it is common for both science and mathematics education researchers to draw on literature from both disciplines, which points to the similarity and translatability of this work across disciplines. For example, there is evidence at the K-12 level that both science and mathematics instructors attend to students process skills or errors as novices and can develop skills for noticing the disciplinary substance of student thinking (e.g., Stockero, 2014; Barnhart & van Es, 2014). Focusing on STEM more broadly will also afford the opportunity to consider disciplinary differences that may arise and would be beneficial to consider in designing and implementing PD to support instructor noticing and responding at the college level.

## Methodology

Faculty from various STEM departments, including Math, Biology, Physics, and Chemistry, who were recognized by their colleagues as individuals who made thoughtful decisions about their teaching were invited and agreed to participate (N=8). Participants were experienced instructors who regularly taught introductory STEM courses. For this proposal, I focus on two participants, Dr. Bio (full professor in Biology) and Dr. Chem (career-line instructor in Chemistry) who taught large enrollment (70 and 270, respectively) introductory STEM courses.

Participants were interviewed before and after a class period which they selected to have filmed (the target class). The pre-observation interview was a semi-structured interview designed to elicit the instructors' goals for class, knowledge of student understanding regarding the topic to be covered, and how this knowledge impacted their planning for class. Clips from the target class (2-5 clips) were selected using selection criteria, and included moments where student thinking was illuminated. These clips were used in the semi-structure post-observation interview to prompt discussion about student thinking and instructional decisions. Interviews were transcribed and analyzed using open coding and thematic analysis to identify emergent themes related to the ways in which instructors notice and respond to student thinking.

## STEM Instructors Eliciting, Noticing, and Responding to Student Thinking

The thematic analysis illustrated similarities and differences between how participants gained insight into student understanding by eliciting student thinking, what was noticed about students' understanding, and then how this enabled or constrained their ability to respond.

### Eliciting Student Thinking

Dr. Bio and Dr. Chem both created opportunities in class for students to share their thinking, though they differed in what their eliciting allowed them to learn about their students' thinking. Dr. Chem strategically designed free response clicker questions to draw out connections and common student errors. She anticipated where students would struggle and leveraged that as an opportunity to engage students. Dr. Chem stated, "I know where they're going to get hung up. So, I purposely designed questions to get them hung up, because I think that if you do it wrong it helps you remember how to do it right." Additionally, before class, Dr. Chem worked through the clicker questions, anticipating common student mistakes, so that she could address these errors in class. She said,

> I calculated the wrong answer beforehand … [because] when the results come in for the question, I look at how many people answered it wrong, and there's more than one wrong way to do it, and I look at the most common ways and address it.

When using clicker questions, Dr. Bio created multiple-choice questions that would set students up to answer incorrectly. He said, "I'm able to set up what I think is a logical straw man for them. They

almost always go for [it]." This type of question does not create an opportunity to elicit student thinking and to gauge how students are thinking about the content.

## Noticing Student Thinking

Dr. Bio and Dr. Chem noticed different things about student thinking. Dr. Bio noticed that students did not always take away the main points that he was trying to communicate, saying:

> Because obviously, I'm focused on them getting this one point. And then somebody is telling me, 'Oh, what about this?' And I was like, that's sort of in there, but that's not where I was going. And sometimes I realize … that where I'm going is not where the class is going.

Dr. Bio did not regularly gauge where students were at with their understanding. Thus, he was limited in what he could notice about student thinking, and did not have an opportunity to understand what constrained students' ability to make the connections he desired. Dr. Bio relied on end of semester surveys for feedback on areas that students felt were challenging; he said,

> [I think about the] student comments from the end of the semester, about their perception of the course being disorganized. So, I have, over the years, taken that to heart as constructive criticism and try to make the connections more apparent and meaningful to them.

This comment highlights that he responds to student confusion by working to improve his course from semester to semester, but he is not equipped with the knowledge or tools to assess how impactful these changes are on student learning.

Dr. Chem notices when students are stuck by their facial expressions, understands what students are likely struggling with, and anticipates how she might respond. She said,

> I put the question up, and then I anticipate they're going to read the question, they're going to start working, and then they're going to look at me really perplexed. I wait until I get the look, and then I ask them if they're stuck and they are. So, I will say, 'do you remember this … from earlier this semester?' And then they go, 'Oh', and then they start working again.

Additionally, Dr. Chem used a variety of approaches (including clicker questions, whole class discussions, eavesdropping, facial expressions, interactions in office hours) to gauge where students were at with their understanding, and thus could adjust her plans for class accordingly.

## Responding to Student Thinking

Dr. Bio and Dr. Chem responded differently based on what they noticed about student thinking. Dr. Bio made changes each semester, but rarely made changes during class or between classes, saying, "I don't always incorporate [it] right on the fly. And sometimes it's a year delay between when I got that question [and] when I can actually address it in class". Since Dr. Bio did not create opportunities to elicit and notice the substance of student thinking, he was constrained in his ability to make changes that were rooted in students' understanding. He discussed putting himself "in the mindset of the student" when bridging parts of class that were disjoint, saying,

> [I am] going through those notes sections [of the slides] and making sure that they are written in such a way that a student looking at that slide, if she's confused by it, should be able to read those notes and come away saying, 'Oh, now I see what this slide is about.'

Although Dr. Bio provided opportunities for students to ask and answer questions during class, if the students' contribution was not what he had thought about prior to the lesson he tended to redirect back to his prescribed plan for the class. For example, Dr. Bio said,

> I figured that kind of response was kind of off base. I mean ... it just kind of threw me. And so that's probably why I immediately, before I lost the thought of - what do I really want to accomplish with this - I just went ahead and told them.

Dr. Bio's vision of what he wanted to accomplish in this class period, and his struggle to connect the students' thinking with his goal, constrained his ability to notice how this student was

understanding the content and the connections that the student was trying to make. Dr. Bio cared about student learning and wanted to improve semester to semester as an instructor, but he did not have the knowledge or the tools to effectively engage with and respond to student thinking.

Dr. Chem regularly made changes from one class to the next, and made changes each semester. Specifically, Dr. Chem planned for instruction based on students' current understanding of the material, stating, "I won't move forward if they're not getting it. There's no reason to. I actually wanted to get farther on Tuesday then I did, but the class wasn't ready to go farther." Dr. Chem also discussed adding clicker questions for the next class to provide students more opportunities to engage with key concepts. Dr. Chem made the following comment after discussing a topic her students were currently struggling with: "I have a new question that will address it. … I've posted the annotated slides so they can see how to do it, but … we're going to do another question that's similar to that [in class]." This comment highlights that Dr. Chem provided her students with the resources to revisit what they were struggling with in addition to creating an additional opportunity to revisit the material. Dr. Chem also discussed making changes from semester to semester, saying,

> I'll take notes of like - 'I'll need to spend more time on this', or '[students] really struggled with this'. Then when I get ready for class the next semester, I go back to that and that's what prompts me to make new slides.

## Discussion

Both Dr. Bio and Dr. Chem were experienced instructors, but they noticed different things about their students' thinking, which then enabled or constrained their ability to leverage and respond to student understanding. Specifically, Dr. Bio noticed that students were struggling to make connections, and did not understand what was underlying these difficulties. Consequently, he was limited in what he could respond to. Dr. Chem noticed specific student struggles and built on her existing knowledge of student thinking. Her awareness of students' understanding enabled her to respond both during in-the-moment instruction and in her planning.

Dr. Bio's goal for instruction was to help students appreciate the connections between the seemingly disconnected content through the sharing of his knowledge. Dr. Chem, on the other hand, viewed her course as an opportunity to challenge common student errors and to support students in developing a more complete and correct way of thinking about the content. Consequently, it seems as if Dr. Bio and Dr. Chem had differing dispositions towards student thinking, which impacted their approach to instruction and the opportunities that they created to notice and leverage student thinking. This highlights that it could be important to foster a responsive disposition that values student thinking when developing PD to support faculty in their ability to elicit, notice, and respond to student thinking.

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## References

Amador, J. (2016). Professional noticing practices of novice mathematics teacher educators. *International Journal of Science and Mathematics Education, 14*(1), 217-241.

Ball, D. L. (2011). Forward. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), Mathematics teacher noticing: Seeing through teachers' eyes (pp. xx-xxiv). New York: Routledge.

Barnhart, T., & van Es, E. (2015). Studying teacher noticing: Examining the relationship among pre-service science teachers' ability to attend, analyze and respond to student thinking. *Teaching and Teacher Education*, *45*, 83-93.

Bok, D. (2013). We Must Prepare Ph.D. Students for the Complicated Art of Teaching. *The Chronicle of Higher Education*, (November 11, 2013). Retrieved from http://chronicle.com/article/We-Must-Prepare-PhD-Students/142893/

Carpenter, T. P., Fennema, E., & Franke, M. L. (1996). Cognitively guided instruction: A knowledge base for reform in primary mathematics instruction. *The Elementary School Journal*, *97*(1), 3-20.

Erickson, F. (2011). On noticing teacher noticing. In Sherin, M., Jacobs, V. & Philipp, R. (Eds.) *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 47-64). New York: Routledge.

Holdren, J. P., & Lander, E. S. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Washington, D.C.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, 169-202.

Sherin, M. G., Jacobs, V. R. & Philipp, R. A. (2011). Situating the study of teacher noticing. In M. G. Sherin, V. R. Jacobs & R. A. Philipp (Eds.), Mathematics teacher noticing: Seeing through teachers' eyes (pp. 3–13). New York, NY: Routledge.

Stockero, S. L. (2014). Transitions in prospective mathematics teacher noticing. In Lo, J., Leatham, K., & Van Zoest, L. (Eds.) *Research trends in mathematics teacher education* (pp. 239-259). Springer, Cham.

Thornton, H. (2006). Dispositions in action: Do dispositions make a difference in practice?. *Teacher Education Quarterly, 33*(2), 53-68.

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571-596.