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A Tool for Becoming Aware of Attending to Students' Thinking: A Precursor to Developing Teacher Noticing

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ABSTRACT

In this paper, we discuss the development and application of an analytical tool for use with teachers to help them become aware of how they attend to students' thinking during discussions. Through understanding how one explicitly attends to student thinking, corrective measures for improving facilitation of effective classroom discussions can occur. The tool is designed as a decision tree, drawing on literature from both science and mathematics education. The application of the tool in this paper uses video from elementary pre-service teachers' instruction in an early field experience. Utilizing science teaching videos from three teaching teams (Grades K, 2, and 5), we demonstrate how the decision tree tool moves beyond an initial teacher question and student response to bring attention to how pre-service teachers follow up on students' responses. Four main branches are identified (focusing, funneling, acknowledging, and no response), with smaller branches for each. To show the potential of the tool, data is also provided on the frequencies of these decision branches from our analysis of the three teaching teams used to develop the tool. Limitations of the tool, but also implications for future use are discussed.

Keywords: attending to student thinking, professional teacher noticing, pre-service teaching and learning, tool for video analysis

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Introduction

Effective science teaching involves teachers understanding how students are making sense of what they are learning (Davis et al., 2020). To do this, teachers must learn to become responsive to their students' needs based on how they are making sense of the phenomenon. A responsive teacher knows how to attend to students' ideas, interpret responses, and respond in a manner that advances student learning (Gotwals & Birmingham, 2016; Kang & Anderson, 2015). These aspects of responsive teaching are strengthened when a teacher is engaged in the practice of "professional noticing" (Sherin et al., 2011; Luna, 2018). Researchers describe the practice of teacher noticing as dynamic and consisting of two activities: (1) giving attention to moments of student thinking in an instructional setting, and (2) making sense of these moments (Luna, 2018). For these two acts to occur, a teacher needs to also consider how they facilitate discussions with students so moments of students' thinking about a particular phenomenon can be brought forward for sense-making (Davis et al., 2020; Windschitl et al., 2018).

To date, much of the research on teacher noticing, and its use in learning to make sense of student thinking, has focused on mathematics education and across a range of contexts – in-service to pre-service and elementary through secondary (see Sherin et al., 2011 for a comprehensive overview). In science education, the concept of teacher noticing has started to gain traction, but it "is still a construct 'under development' without an established definition" (Chan et al., 2021, p. 2). Of the studies in science education that have included specific reference to teacher noticing, more attention is given to studying secondary teachers than primary, but there is a balance in representation between in-service and pre-service teacher studies (Chan et al., 2021). Since Chan et al.'s review, some researchers in science education have started to explore how different practice spaces, such as peer rehearsals (Benedict-Chambers et al., 2020) or online simulations (Lottero-Perdue et al., 2024) can support teacher noticing. Furthermore, there is recent research focusing on secondary science and mathematics pre-service teachers learning to professionally notice as they facilitate discussions within simulated environments and with a focus on argumentation (Zangori et al., 2025).

What is missing within the literature on teacher noticing are analytic tools that can be used with teachers to support attending to students' thinking in the act of facilitating classroom discussion. With the prevalence of approximations of practice (i.e., rehearsals and simulations) in teacher preparation programs, having an analytical tool such as the one described in this paper can provide critical support for pre-service teachers with learning to explicitly identify strategies for interpreting and responding to students and enhance sense-making. Specifically, how are teachers framing questions that follow up a student's response that may help to advance the discussion, redirect the discussion, or, in some cases, unintentionally shut down a discussion. Understanding how to move a discussion beyond the initial question asked is an important precursor for learning how to professionally notice in the act of teaching. The decision tree tool discussed in this paper was designed to meet this need. The tool is easily adaptable in various contexts as it uses video of classroom practice as the medium for analyzing how the teacher is attending to students' thinking in the discussion. In fact, the Zangori et al. (2025) study employed this analytical tool to analyze the secondary mathematics and science pre-service teachers' communication patterns around argumentation. Therefore, the purpose of this paper is to describe the development of the tool and illustrate the possible information that can be gleaned about teachers' attention to students' thinking. To accomplish this goal, 14 teaching videos from three teams of elementary science pre-service teachers' instruction during an early science field experience were used.

Conceptual Framing and Related Literature

Based on the evaluation of a 10-year research-based curriculum improvement project, as well as work with beginning teachers, Davis and Smithey (2009) outline three areas of focus for the development of pre-service elementary science teachers, "a) inquiry-oriented science teaching, b) use of science curriculum materials, and c) anticipating and working with student ideas during instruction" (p. 745). It is the third area that necessitates pre-service teachers to become aware of how they are attending to students' responses during the act of teaching, so they can begin to work towards the more complex practice of professional noticing in the act of teaching.

Professional Noticing

Professional noticing serves as the conceptual framework for the development of the tool described in this paper. Professional noticing, or teacher noticing, first gained acceptance in the field of mathematics education with the work of Sherin and van Es on teachers watching and discussing video of their own classrooms (see Sherin, 2001; 2007; Sherin & van Es, 2005; 2009; van Es & Sherin, 2002; 2006). To notice student thinking involves "(a) identifying what is important or noteworthy about a classroom situation; (b) making connections between the specifics of classroom interactions and the broader principles of teaching and learning they represent; and (c) using what one knows about the context to reason about classroom interactions" (van Es & Sherin, 2002, p. 573). For beginning teachers, however, it can be difficult to navigate the many complex skills of professional noticing when there are so many different pedagogical challenges when first learning to teach (Amador et al., 2021; Davis et al., 2006). One of these challenges is learning to be in the moment and listening to what students are saying to decide how to effectively respond. Levin et al. (2009) refer to this act of responding in the moment as attending to students' thinking. This pedagogical move requires teachers to listen to what students are saying in response to questions asked and be able to think in the moment about how to follow up to probe students' thinking further. This skill of knowing how to follow up is important because it is what offers teachers insight into students' thinking and affords them the information needed to learn to develop the more complex noticing skills of 'interpreting' and 'responding' (Jacobs et al., 2010) more effectively. It is important to recognize the various influences that make it challenging for pre-service teachers to develop these complex noticing skills.

Research in science education has increasingly examined how noticing operates in the context of science teaching, where teachers must attend to both general pedagogical cues and the disciplinary dimensions of students' scientific ideas, reasoning, and practices to support their scientific sensemaking (Chan et al., 2021; Russ & Luna, 2013). Science learning is dynamic and context-dependent, requiring teachers to adapt instruction in response to students' evolving ideas (Russ & Luna, 2013). This need for flexibility aligns with research on formative assessment, which underscores that effective noticing involves eliciting, interpreting, and using students' thinking as evidence to make real-time instructional adjustments (Black & Wiliam, 2009).

Noticing in science is influenced by teachers' content knowledge, pedagogical content knowledge (PCK), epistemological framing, and teaching experience (Chan et al., 2021). Luna (2018) emphasized that noticing in science classrooms requires more than identifying correct answers; it demands attention to the disciplinary substance of students' reasoning, which is often implicit and requires interpretation in the moment. Noticing also varies across classroom settings, including whole-class discussions, small-group work, and laboratory investigations (Russ & Luna, 2013).

Despite its importance, novice science teachers often struggle with noticing. Levin et al. (2009) found that beginning teachers can attend to student thinking when supported by environments emphasizing responsive teaching and sensemaking. However, school contexts focused on curriculum coverage and classroom control can undermine these practices. Barnhart and van Es (2015) demonstrated that pre-service secondary science teachers who engaged in video-based analysis developed more sophisticated noticing, particularly in attending to student ideas, analyzing interactions, and proposing responsive instructional moves, than those who did not. However, responding effectively remained the most difficult aspect. Similarly, Luna (2018) observed that elementary science teachers varied in their capacity to notice the disciplinary value in students' ideas, highlighting the need for tools to support pre-service teachers in developing disciplinary noticing skills (Amador et al., 2022).

Although research has established the importance of teacher noticing for eliciting and interpreting student thinking, studies consistently show that responding in-the-moment remains a significant challenge, particularly for pre-service and novice teachers (Barnhart & van Es, 2015; Levin et al., 2009). In science classrooms, this challenge is amplified as teachers must attend to both the substance of students' disciplinary ideas and the epistemic quality of their reasoning while making real-time instructional decisions (Berland et al., 2019; Russ & Luna, 2013). Existing supports, such as video-based reflection and frameworks emphasizing noticing components (Sherin & van Es, 2009; Jacobs et al., 2010), often focus on retrospective analysis rather than immediate instructional guidance. There is a need for tools that bridge the gap between noticing and action during instruction by supporting teachers as they decide how to probe, extend, or scaffold student thinking in real-time. Therefore, this study introduces a decision tree tool designed to fill this gap by providing structured, practical support for pre-service teachers as they respond to students' science ideas during classroom discussions.

Recent work further emphasized the epistemic quality of student ideas as central to noticing in science. Berland et al. (2019) proposed Epistemologically Responsive Science Teaching (ERST), which encourages teachers to notice and respond to the clarity, consistency, and causality (3Cs) within students' scientific thinking. Attending to these epistemic dimensions helps teachers recognize how students' ideas align with scientific sensemaking and supports their engagement in Next Generation Science Standards-aligned practices such as modeling, argumentation, and data analysis. ERST provides pre-service teachers with a coherent structure for lesson planning, real-time noticing, and assessment, helping them to see scientific practices as interconnected rather than isolated.

Further expanding on the relationship between noticing, PCK, and equitable teaching practices, additional studies reveal that novice elementary teachers frequently elicited student thinking but struggled to use that information to guide instruction, especially in science, compared to mathematics (Amador et al., 2022). Benedict-Chambers and Sherwood (2024) similarly emphasized the need for equity-oriented noticing, finding that pre-service teachers often engaged in surface-level descriptive noticing but required support to progress toward evaluative and interpretive noticing, which considers how lesson designs position students as active knowledge constructors.

Within elementary classrooms specifically, much of the interaction around student thinking occurs through verbal exchanges between the teacher and student, or students and students, with the teacher listening (Kelly, 2014). Concerning these patterns in classroom dialogue, Nicol (1999) noted that when pre-service teachers were prompted to examine the questions they asked during their exchanges with students, the pre-service teachers found they asked more yes/no questions rather than probing questions and that their desire to listen for what was expected overshadowed their ability to listen to student reasoning and thinking. Nicol also explained that the preservice teachers recognized deficiencies in both their questioning and listening to student answers and attributed it to their fear of the lesson moving away from their pre-planned instruction. Levin et al. (2009) noted from their study that for pre-service teachers, the issue of learning to attend to students' responses relates to how they are framing their practice. Framing guides what teachers focus their attention on when examining what is happening in the classroom. Unless teachers "frame" their instruction around student thinking, they may not develop the necessary skill of attending to student thinking. Lastly, from their analysis of pre-service teachers' abilities to attend, analyze, and respond to students' thinking, Barnhart and van Es (2015) concluded that for pre-service teachers to provide high levels of analysis and responses to student ideas, they needed to demonstrate sophisticated levels of initially attending to student ideas. Each of these studies demonstrates the importance of first building the skill of learning to attend to students' thinking within discussion and the need to become aware of how they are following up on students' responses to elicit student thinking. For this awareness to develop, beginning teachers, such as pre-service teachers, need to learn about the purpose of questioning and framing of questions.

The Role of Questioning

Certain types of questions can help scaffold students' thinking, assisting them in developing solid conceptual understanding, while others serve only to assess correctness. This first type of questioning is useful because it helps to facilitate learning by giving implicit feedback that further challenges student understanding (Brown & Abell, 2007; Harlen, 2015). It also helps to stimulate more elaboration and productive student responses, leading students to deeper conceptual understandings.

Chin (2006) developed an analytical framework to represent classroom talk and questioning in science to examine how teachers use questioning to engage their students in thinking about content to foster their construction of knowledge. Chin identified various forms of feedback provided by in-service teachers in their follow-up moves during initiation-response-follow-up (IRF) exchange formats (Mehan, 1979). The follow-up moves that generated the most productive student responses were the ones that were non-evaluative and utilized further questioning to elicit deeper thinking (Chin, 2006). Teachers' questions that scaffold students' thinking and lead them to conceptual understanding provide a much greater benefit than those that simply assess correctness.

Another study in mathematics education examined student-teacher interactions in reform-based classrooms where students are encouraged to investigate and share their mathematical thinking (Wood, 1998). In their study, Wood discussed interaction patterns between in-service teachers and students that either encourage or restrict mathematical meaning construction. One specific interaction pattern, initially identified by Bauersfeld (1980), is called the funnel pattern. In the funnel pattern, teachers have a specific answer and/or way of thinking about the content that they are attempting to lead students to state. Asking funneling questions guides students to one determined correct answer rather than encouraging students to share their thoughts about how they are constructing their understanding and application of the mathematical task. Conversely, when teachers follow a different interaction pattern, which Wood (1998) called a focusing pattern, teachers allow students to share their reasoning and thinking without the goal of any specific predetermined answer. Although in both the funneling and the focusing patterns, teachers ask questions of students, only in the focusing pattern are students encouraged to share their strategies and reflect on their mathematical knowledge construction. Focusing questions encourage students to take an active role in making sense of mathematics and remove the imposed limit of only one correct answer. Through asking focusing questions, teachers can examine student thinking and encourage sense-making.

Drawing on this body of literature, we sought to develop an analytical tool to use with video of classroom discussion. We refer to this tool as a decision tree that teacher educators can use with pre-service teachers to develop awareness of how they are initiating dialogue with students (i.e., the initial question) *and* how they follow up the students' responses to promote further discussion and sense-making. The remainder of this paper focuses on describing how the decision tree tool was developed through analysis of multiple video segments of elementary pre-service teachers' early science field experience.

Development of the Analytical Tool

Context and Selection of Videos

The video used for the development of the tool was captured over two semesters during a multi-year NSF-funded Iterative Model Building (IMB) Project (see acknowledgement). The first author in this study was a Co-PI for this project, and the other authors were doctoral students at the time in a class that the first author was teaching. The class involved learning about how to become a science or mathematics teacher educator. The second through fifth authors and the seventh author divided into three teams to review two recorded science lessons taught by three different groups of pre-service teachers. The sixth author in this study provided support with the literature review and conceptual framework for the field of mathematics education.

Taking a case study perspective (Yin, 2009), we selected three teams (cases) of elementary pre-service teachers who had participated in the IMB Project. A total of 14 science lessons across three teams were recorded and all had provided consent for their videos to be used for research purposes. The elementary schools the pre-service teachers taught in for their early field experience were in the same town as the large research university the pre-service teachers attended for their teacher education program. One team (or case) taught in a fifth-grade classroom, another in a second-grade classroom, and the third in a kindergarten classroom. In total, there were 17 females and one male, and 17 of the participants were Caucasian and one was African American. In addition, one of the female participants had selected science as her content area of concentration for her elementary teaching program requirements. This meant that she was required to take one additional science course, a philosophy of science (Nature of Science) course, and one additional science methods course targeting upper elementary/middle grades. However, she did not complete this second methods course until after the semester in which the field experience, where the video for this study was recorded, was taken.

Each week, two to three members of the pre-service teacher teams took the lead in facilitating the science lesson with the class of elementary children. The other team members served as observers or small group assistants. The pre-service teachers leading the instruction of each week's lesson typically split the lesson up into parts, so each person was solely implementing a component of the lesson with the whole class of students. This splitting up of duties allowed for the analysis of one teacher for each segment of the lesson, which helped when identifying the dialogic interactions for the development of the tool, as it was one teacher interacting at a time with the class of students. The videos analyzed included five science lessons on Properties of Fabrics (Kindergarten), five lessons on Properties of Matter (2nd grade), and four lessons on Models and Design using forces on flight for context (5th grade). Each of these topics was requested by the corresponding classroom mentor teacher to align with the school district's adopted science curriculum.

Phase One – Beta Testing Codes

Given the video we were using to develop the tool was of pre-service elementary teachers' science teaching, our first phase of coding was informed by Levin et al. 's (2009) definition of attending to student thinking, which they described as a teacher "notic[ing] and respond[ing] to a student's idea" (p. 147). They further explained different ways teachers can respond including: 1) asking a student or other students to explain or elaborate on an idea, 2) rephrasing what the student shared, and 3) shifting the lesson to address the idea shared (Levin et. al., 2009). We utilized these descriptions initially as the codes for understanding how the pre-service teachers were attending to student thinking in the act of teaching. In addition to the three attending codes, we also developed the code 'acknowledging' to document the ways that pre-service teachers were not attending to student thinking in their instruction. 'Acknowledging' meant that the pre-service teacher gave little to no consideration as to what the student said before returning a response. Therefore, the teacher's response for an acknowledging code included providing general praise, evaluating the answer, or asking the student to repeat the response. See Table 1 for a summary of the four levels of coding and their descriptions for the first round of a priori coding used in the development of the tool.

Table 1

Initial Draft of Codes Developed for Analytical Tool Adapted from Levin et al., 2009

Code	Definition
Acknowledging	The teacher did not consider what the student said before returning a response that suggested they were not fully listening.
Attending - shift	The teacher hears the topic and makes a related comment in return, but then shifts or pivots to a new topic with the next question.
Attending - rephrasing	The teacher takes what the student said and rephrases it to help others understand or asks the student who shared if the rephrased statement accurately represents what they were saying.
Attending - elaborate	The teacher shifts the attention to a student peer to repeat or elaborate on the statement the initial student made.

To begin with the a priori coding noted in Table 1, each pair of coders prepared transcripts from watching the videos for the first two lessons taught by the team of pre-service teachers they were assigned to. Using these transcripts, Authors 2-5 and 7 coding partners first met to identify episodes in the transcript demonstrating an initiation- response- follow-up (IRF) exchange (Kelly, 2014). Identifying these exchanges was important to give boundaries for coding and to ensure each episode included a teacher initiating with a question, a student responding, and then the teacher following up. It is how the teacher responds to the follow-up segment and utilizes the conversation for instruction that the decision tree tool serves its purpose. The ending of an episode was identified as ending when no further or substantial ideas were being shared by students, or a new topic was identified. Therefore, some episodes are longer than others, and episodes could be between the teacher and one student or the teacher and several students. We did not move to the next level of analysis until the team was in 100% agreement as to this definition of identifying an episode, and each coding pair agreed on the identification of episodes, using this definition, for their assigned videos/transcripts.

The next step involved the coding partners 1) individually coding a whole transcript for lesson one, then 2) coming together and reconciling their results. This was repeated for lesson two. A coder first needed to identify within each identified episode if the pre-service teacher leading the discussion indeed was showing some attention to student thinking in their follow-up response to the student's comment. This became the first level of the decision tree: Does the teacher attend to the student's thinking? Referring to codes generated from Levin and colleagues, this first level of coding determined whether the coders would move down the path of yes – and possibly one of the three 'attending' codes described in Table 1, or no, move to the acknowledging code instead. Codes associated with acknowledging follow-up emerged through this process.

During this beta-testing phase of coding, the coders were asked to also highlight any exchanges that they did not feel aligned with codes and/or subcodes on our initial coding structure

(Table 1). When Author one and the three sets of partner coders came together to reconcile their codes for the beta-testing phase, they discussed any of these highlighted exchanges until 100 % agreement was reached. From these discussions, we noticed there were more nuanced examples of how the pre-service teachers were attending to student thinking, and not attending to their thinking, than our initial coding tool (Table 1) allowed for. Therefore, to better understand how a teacher considers a student's ideas before responding, we further explored the research base and found two variations in the mathematics education literature on communication patterns that captured the distinct differences in 'attending to student thinking' we identified from the first round of analysis. These variations are described further in the next section as we explain refining the coding process.

Phase Two - Refining the Coding Schema

It was through this refining process that we began to identify the tool as a decision tree because more than one decision needed to be made beyond the initial question of whether the pre-service teacher was attending to students' thinking. Through this refinement process, additional sub-codes (or smaller branches of the tree were identified).

To begin the refinement process, the research team drew on the work of Wood (1998) in mathematics education that discusses communication patterns in the classroom. The first variation of attending to students' thinking we adopted from Wood was the notion of 'funneling', which refers to a teacher using well-intentioned questions to guide or focus students' thinking to a particular outcome. The second variation of attending to students' thinking was the concept of 'focusing', which involves the teacher creating situations for classroom talk that allows students to explain and give reasons for their science ideas. To further expand on each of these codes, the researchers returned to the previously coded transcripts for the first two videos of lessons taught by each pre-service teaching team. Again, coding partners individually reviewed the identified bounded episodes using the new three-level coding schema of focusing, funneling, and acknowledging. Within each of these coded segments, which we refer to in the decision tree as a branch, additional emergent coding occurred to identify different examples of focusing, funneling, and acknowledging. These examples became the smaller branch decisions in the tool. Allowing for the emergent coding also afforded the opportunity to look for various ways that attending to students' thinking and for different purposes can occur. This process also led to identifying a second larger branch of not attending to student thinking, which we called 'no response'. This non-attending branch, just as the title suggests, was coded in contrast to acknowledging and examples of it occurred when the pre-service teacher made follow-up comments that showed no consideration of the student's comment. This could include affirmatory or ignoring the comment, and otherwise, but it often resulted in shutting down the discussion or completely changing the direction of the discussion.

As coding partners came together, and then the larger research team, to discuss these examples, we were able to condense emergent codes across all four main branches (funneling, focusing, acknowledging, or no response), provide definitions for each, as well as the smaller branches coming from each. These definitions and examples of each from episodes identified in the data were reached with 100% agreement among the research team and are provided in Appendix A.

The recursive process the research team used to generate this code book for the decision tree helps to ensure inter-rater reliability and validity in the coding process and applicability of the tool across grades and topics. Because of the tiered analysis process, specific inter-rater reliability calculations were not made, as the goal was to reach agreement across all of our identified episodes to produce a comprehensive tool. For the final step, and to determine saturation in the definitions for each branch of the tool, the coding partners returned to the final three lessons taught by each pre-service teaching team and applied the decision tree tool to ensure no additional codes emerged.

Codes identified in the tree represented each of the follow-up responses a teacher provided, thus a point of saturation in coding was reached.

Final Steps of Development and Application

In the end, three smaller branches were identified for the main 'focusing' branch, four smaller branches were identified for each of the funneling and acknowledging main branches, and the fourth main branch, 'no response', also had three smaller branches stemming from it. Each main branch and the smaller branches extending from them are described below.

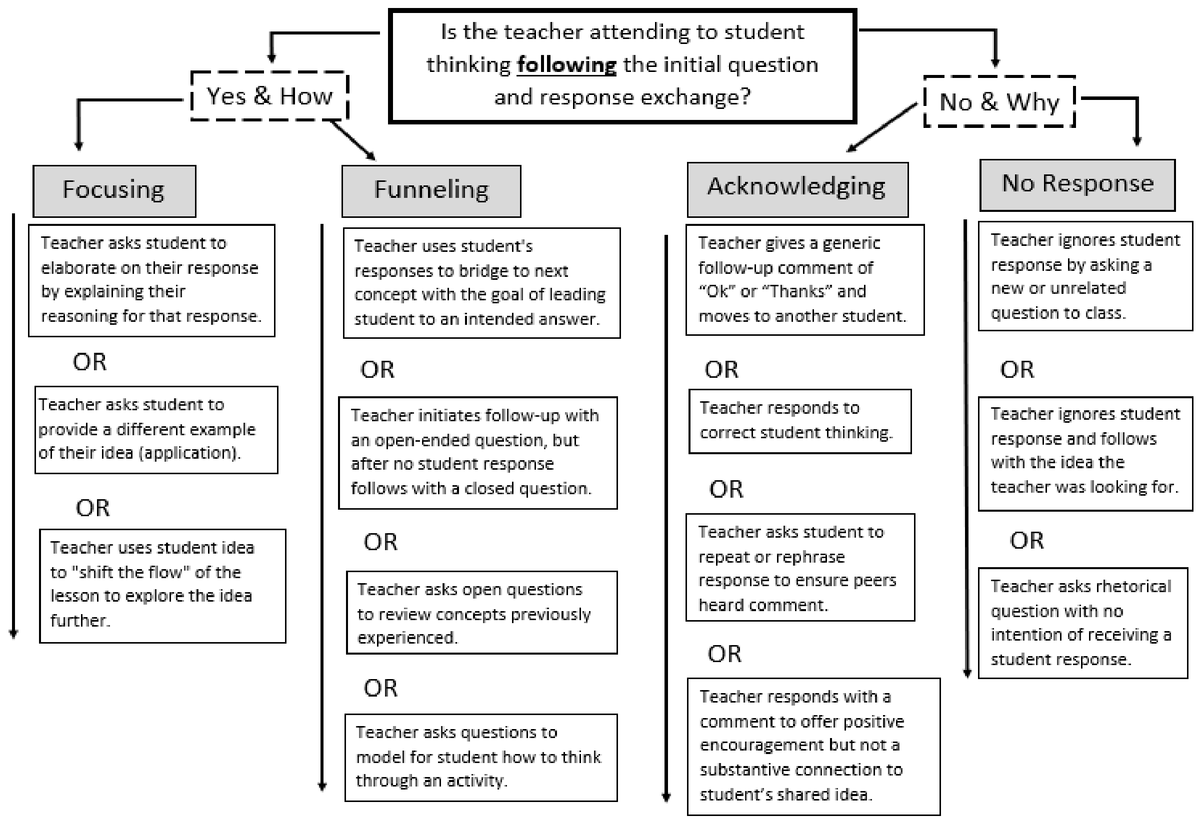
1. *Focused, attending*: When pre-service teachers were focused on what the students were saying they would: 1) ask students to elaborate on their response and explain their reasoning, 2) ask students to provide an application of their idea, or 3) shift the flow of the lesson to explore a student's idea further.
2. *Funneled, attending*: When the pre-service teachers funneled students' ideas towards a specific learning outcome they would: 1) use the student responses to bridge to the next concept to lead students to the intended answer; 2) ask an open-ended question, but after no response follow-up with a closed question; 3) ask an open-ended question to review past concepts; 4) ask questions that are intended to model for students how they should be thinking through an activity.
3. *Acknowledging, not attending*: For this branch it was observed that the pre-service teachers responded to a student's comment by: 1) recognizing the student said something but not fully paying attention to what was said because their next follow-up comment was unclear, unrelated, or referenced only a part of the student's idea; 2) paying attention to what was said but for correctness; 3) paying attention to what was said but only to motivate or encourage the student to participate; 4) asking students to repeat or rephrase their responses to ensure it was heard by others but no connection was made to the idea the student shared.
4. *No response, not attending*: This branch included examples of when the pre-service teacher 1) clearly ignored a student's response by asking a new and unrelated question, 2) stated the idea to the students' they were looking for as a student response; 3) asked a rhetorical question as a follow-up to the student's response. Although this type of exchange suggests limited communication, we believe it is important to include this code, as it affords teachers the ability to recognize *how* teacher responses to a student comment can also cause communication patterns to be limited or even stopped.

Figure 1 illustrates the decision-tree tool, showing these four main branches coming from the initial question: *Is the teacher attending to students' thinking in the discussion?* If the answer to this question is yes, then the teacher follows the left path on the decision tree to code for how. If the teacher is not attending to students' thinking, then follow the right path of the decision tree to identify why. We recommend this tool be used with video, and preferably transcripts of the video, if available. Having both the video of instruction and the transcripts can make it easier for first bounding episodes for coding. However, it could potentially be used as an in-the-moment observation tool, but with space provided for documenting frequency counts and perhaps a section for notes to summarize an example of one exchange to illustrate a decision most frequently made by a teacher in discussion with students.

We also recognize the smaller branches under each of the four main codes are not an exhaustive list of possible responses a teacher may give in following-up from a student's comment, but these branches (or examples) were reached through an iterative process of reaching saturation across the 14 videos for the data set we had access to for this study. Therefore, depending on whether the tool is used with pre-service teacher video or exemplary teacher video, it is possible that additional smaller branches of interactions could be found. The design of this tool allows for this kind of flexibility.

Figure 1

Decision Tree Tool for Developing Awareness About Attending to Students' Thinking During Discussions



What We Learned About Pre-service Teachers' Attention to Students' Thinking

To illustrate the potential of information that can be gleaned from using the tool with pre-service teachers' own teaching video, we kept records of our coding results across the three teams of pre-service teachers. The purpose of this section is to share these results to illustrate the potential use and outcomes of the tool.

In total, there were 291 coded Initiate-Respond-Follow-up (IRF) segments, or what we refer to as the bounded episodes of classroom dialogue. This number of episodes includes the coding across all three teaching teams (cases) for the full set of 14 lessons. Of the 291 episodes, the kindergarten case had 101 coded episodes in five lessons, the second grade case had 110 coded episodes in five lessons, and the fifth grade case had 80 coded episodes across their four lessons. Table 2 provides a breakdown of how these episodes were identified across the four main branches of focusing, funneling, acknowledging, and no response, and the smaller branches for each case.

Table 2

Frequencies by All Branch Levels Compared Across All Three Teaching Teams

Decision Tree Branches – Main and Smaller Branches	Grade K (n=101)	Grade 2 (n=110)	Grade 5 (n=80)
No response			
Teacher ignores student response by asking a new or unrelated question to class.	5	2	3
Teacher ignores student response and follows with the idea the teacher was looking for	8	3	3
Teacher asks rhetorical question with no intention of receiving a student response.	4	4	0
Totals	17	9	6
Acknowledging			
Teacher gives a generic follow-up comment of "Ok" or "Thanks" and moves to another student.	6	9	2
Teacher responds to correct student thinking	15	39	16
Teacher asks student to repeat or rephrase response to ensure peers heard comment.	3	3	3
Teacher responds with a comment to offer positive encouragement but not a substantive connection to student's shared idea.	18	30	12
Totals	42	81	33
Funneling			
Teacher uses student's responses to bridge to next concept with the goal of leading student to an intended answer.	16	10	25
Teacher initiates follow-up with an open-ended question, but after no student response follows with a closed question.	5	7	2
Teacher asks open questions to review concepts previously experienced.	7	2	2
Teacher asks questions to model for student how to think through an activity.	6	0	0
Totals	34	19	29
Focusing			
Teacher asks student to elaborate on their response by explaining their reasoning for that response.	7	0	11
Teacher asks student to provide a different example of their idea (application).	0	1	1
Teacher uses student idea to "shift the flow" of the lesson to explore the idea further.	1	0	0
Totals	8	1	12

Of the four main branches, we found that most of the episodes (156 of 291 total or 53.6%) were coded to acknowledging. More specifically, the second grade case had 81 of their 110 (73.6%) coded as acknowledging; whereas the kindergarten case had 42 of their 101 coded episodes (41.6%), and the fifth grade case had 33 of their 80 episodes (41.3%) coded as acknowledging. Examining this difference between the second grade case and the other two cases further, we see the second grade case had many more episodes coded for responding to correct thinking by students or offering positive encouragement of a response, despite the quality of what the student said. This suggests the pre-service teachers on the second grade team, compared to the other two cases, either viewed their purpose for questioning to ensure accurate answers were shared, or that they struggled with asking questions that went deeper in understanding students' thinking. Becoming aware of and understanding the reasons for these patterns can provide critical information for teacher educators, or even a teacher themselves, to try and plan for better follow-up responses that will extend the conversations further and build more or connect more with different students' ideas.

The second main branch in total frequencies was attending to branch of funneling. Overall, this branch received 28.2% (82 of the total 291) of the coded episodes. Specifically, the kindergarten case had 34 of 101 coded episodes (33.7%) to this category, second grade had 19 of 110 coded segments (17.3%), and fifth grade had the highest frequency with 29 of 80 coded episodes (36.3%) as funneling. Of the smaller branches coming from funneling, the one receiving the most coded episodes was – *Teacher uses student's responses to bridge to next concept with the goal of leading student to an intended answer*. This smaller branch received 51 of the total 82 (62.2%) coded episodes for funneling. These findings suggest that the pre-service teachers across all three cases valued hearing students' ideas, and to bridge from one student's idea to the next concept, and often to lead the conversation to a specific goal. Being aware of this communication pattern offers teacher educators and teachers opportunities to discuss alternative questioning techniques with teachers that could foster more sense-making opportunities to build students' ideas collectively and press for more evidence-based explanations (Windschitl et al., 2018). Identifying these patterns can also open up the opportunity to show teachers how to use more productive wait time before responding to a student's comment.

The main branch with the fewest total coded episodes was focusing. The smaller branches associated with this main branch also demonstrate the most connection to students' thinking is being attended to, in such a way that it is driving the communication pattern. Overall, fifth grade had 12 of their 80 episodes (15%) coded to the focusing branch, kindergarten had 8 of their 101 coded episodes (7.9%) coded to this branch, and second grade had 1 of their 110 episodes coded to this branch (0.9%). Becoming aware that the attending branch of focusing is the branch that teachers are least demonstrating an ability to support as a communication pattern is telling for teacher educators. This branch is the one that is most likely to support students to engage in the discussion for sense-making purposes and build reasoning about the science concepts by connecting the students' ideas (Davis et al., 2020). Thus, more attention needs to be given in teacher education programs on how to help novice teachers navigate these complex patterns of classroom talk (Abell et al., 2010; Davis et al., 2020; Gallas, 1995).

These results illustrate the potential for information that can be produced using the decision tree tool. This kind of information can provide not only teacher educators with a broad view of how their pre-service teachers are responding to student thinking but also bring awareness to pre-service teachers themselves if they were to use this tool to analyze their own teaching video. Reflecting on this information about how, and why, a teacher is attending to (or not attending to) students' thinking in the act of teaching can help to develop awareness of what are both the strengths and weaknesses in one's practice (Gotwals & Birmingham, 2016). Additionally, it can assist with understanding questions that work well to initiate discussions and welcome student comments that can then be attended to more easily (Elstgeest, 2001). In turn, this can lead to more productive classroom discussions (Gallas, 1995). In conclusion, understanding this more detailed level of analysis, which the decision tree tool offers, affords teacher educators a starting place to talk with their preservice teachers about *attending* to students' ideas as the critical first step or precursor to professional noticing.

Limitations and Next Steps

Although this tool has the potential to significantly contribute to the field of teacher education, we recognize that the process used to develop the tool has some limitations. First, we developed this only using elementary pre-service teacher videos. To determine if it is applicable for use with middle or secondary contexts, the tool would need to be tested with video in those contexts. Recently, the first author published a piece with a collection of secondary mathematics and science teacher educators (Zangori et al., 2025). Second, with the focus on pre-service teachers practice as the context, it is uncertain if all these smaller branches would also show for in-service teachers, especially exemplary classroom teachers. Again, the tool should be applied to videos of these teachers' practice determining its utility for these contexts. Given the initial purpose of this tool was to provide teacher educators and/or their pre-service teachers with a user-friendly tool for analyzing practice and to become aware of their attention to (or no attention to) students' thinking in their novice teaching contexts, the data reported from the application of the tool with the three teams of pre-service teachers illustrates the tool meets this purpose.

Furthermore, our tool was designed primarily to identify pre-service teachers' attention to student thinking. However, recent research highlights that noticing in science classrooms must also account for the epistemic and equity dimensions of student sensemaking (Berland et al., 2019; Benedict-Chambers & Sherwood, 2024; Rosebery et al., 2016). Future adaptations of the tool could incorporate these dimensions to better capture the complexity of science classroom interactions and support teachers in making responsive and equity-oriented instructional moves.

Regarding future use for the decision tree tool, using it to compare different levels of expertise in teaching science could be a productive approach to developing pre-service teachers' ideas about how to hold science talks (Gallas, 1995). Many elementary teachers' own science learning experiences perhaps followed more traditional approaches with less emphasis on understanding scientific reasoning, and thus their knowledge of how to talk about science ideas may be limited (Appleton & Kindt, 2002). Holding these discussions in the context of their pre-service science methods class may help to develop their identities as teachers of science because they are engaged in the act of professional noticing with peers (Abell et al., 2010; Davis & Smithey, 2009; Jacobs et al., 2010; Sherin & van Es, 2009).

Additionally, longitudinal research could trace pre-service teachers' noticing development from their initial teacher education into their early years in the classroom, addressing calls for such studies (Barnhart & van Es, 2015; Chan et al., 2021). Such research could illuminate whether tools like this support sustained growth in teachers' capacity to notice and respond to students' ideas as they transition into in-service teaching. Furthermore, examining how pre-service and early career teachers' epistemological framing of their noticing practices could provide deeper insight into how noticing tools interact with teachers' beliefs (Luna, 2018; Russ & Luna, 2013).

Finally, in addition to its use with pre-service teachers, we believe this tool has great potential for supporting in-service teacher development. For many of the same reasons this tool could benefit pre-service teachers in developing their awareness of how they are attending to student thinking, this tool could also assist in-service teachers with learning how they facilitate classroom interactions to promote students' scientific thinking (Sherin & van Es, 2005; Talanquer et al., 2013). For example, teachers could use this tool within the context of professional learning communities to support one another by identifying patterns in their classroom conversations with students (Lave, 1991). For professional developers working with in-service teachers, this tool could help them initially identify individual teacher needs to target in their professional development projects. This level of identification would enable professional developers to track changes in teachers' practice throughout the project and determine if teachers are meeting the professional development goals.

Moreover, integrating the tool into professional development settings where teachers collaboratively analyze video records of their own and others' classrooms could enhance its impact (Barnhart & van Es, 2015; Sherin & van Es, 2009). Research suggests that video-based professional development fosters teachers' ability to attend to the substance of student thinking and reflect on their own practice (Amador et al., 2022; Sherin & van Es, 2005). Professional development using the tool could also emphasize the importance of equity-focused noticing, encouraging teachers to consider how their instructional moves position students as capable contributors to scientific discourse (Benedict-Chambers & Sherwood, 2024; Rosebery et al., 2016).

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References

Abell, S. K., Appleton, K., & Hanuscin, D. (2010). *Designing and teaching the elementary science methods course.* Routledge.

Amador, J. M., Bragelman, J., & Castro Superfine, A. (2021). Prospective teachers' noticing: A literature review of methodological approaches to support and analyze noticing. *Teaching and Teacher Education, 99*, Article 103256. https://doi.org/10.1016/j.tate.2020.103256

Amador, J., M., Park Rogers, M., Hudson, R., Phillips, A., Carter, I., Galindo, E., & Akerson, V. (2022). Novice teachers' planning and implementation of mathematics and science instruction to build on students' thinking. *Teaching and Teacher Education, 115*. https://doi.org/10.1016/j.tate.2022.103736

Appleton, K., & Kindt, I. (2002). Beginning elementary teachers' development as teachers of science. *Journal of Science Teacher Education, 13*, 43-61. https://doi.org/10.1023/A:1015181809961

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. https://doi.org/10.1016/j.tate.2014.09.005

Bauersfeld, H. (1980). Hidden dimensions in the so-called reality of a mathematics classroom. *Educational Studies in Mathematics, 11*, 23-41. https://doi.org/10.1007/BF00369158

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (formerly: Journal of Personnel Evaluation in Education)*, *21*, 5-31.

Benedict-Chambers, A., Fick, S. J., & Arias, A. M. (2020). Pre-service teachers' noticing of instances for revision during rehearsals: A comparison across three university contexts. *Journal of Science Teacher Education*, *31*(4), 435–459. https://doi.org/10.1080/1046560X.2020.1715554

Benedict-Chambers, A., & Sherwood, C. A. (2024). Planning for equitable student sensemaking: An examination of preservice teachers noticing of elementary science lesson plans. *Journal of Science Teacher Education*, *35*(8), 862-882.

Berland, L. K., Russ, R. S., & West, C. P. (2019). Supporting the scientific practices through epistemologically responsive science teaching. *Journal of Science Teacher Education*, *31*(3), 264-290.

Brown, P. L., & Abell, S. K. (2007). Perspectives: Examining the learning cycle. *Science and Children, 45*(5), 58-59.

Chan, K. K. H., Xu, L., Cooper, R., Berry, A., & van Driel, J. H. (2021). Teacher noticing in science education: Do you see what I see? *Studies in Science Education*, *57*(1), 1–44. https://doi.org/10.1080/03057267.2020.1755803

Chin, C. (2006). Classroom interaction in science: Teacher questioning and feedback to students' responses. *International Journal of Science Education, 28*, 1315-1346. https://doi.org/10.1080/09500690600621100

Davis, E. A., Zembal-Saul, C., & Kademian, S. M. (Eds.) (2020). *Sensemaking in Elementary Science: Supporting Teacher Learning*. Routledge, Taylor & Francis Group, Publishers.

Davis, E. A., & Smithey, J. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education, 93*, 745-770. https://doi.org/10.1002/sce20311

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, *76*(4), 607–651. https://doi.org/10.3102/00346543076004607

Elstgeest, J. (2001). The right question at the right time. In W. Harlen (Ed.), *Primary science…taking the plunge: How to teach primary science more effectively for ages 5 to 12*, 2nd Ed. (pp. 36-46). Heinemann.

Gallas, K. (1995). *Talking their way into science: Hearing children's questions and theories, responding with curricula*. Teachers College Press

Gotwals, A.W., & Birmingham, D. (2016). Eliciting, identifying, interpreting, and responding to students' ideas: Teacher candidates' growth in formative assessment practices. *Research in Science Education, 46*, 365–388 (2016). https://doi.org/10.1007/s11165-015-9461-2

Harlen, W. (2015). *Teaching science for understanding in elementary and middle schools.* Heinemann.

Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 4*, 169-202. https://doi.org/10.5951/jresematheduc.41.2.0169

Kang, H., & Anderson, C. W. (2015). Supporting pre-service science teachers' ability to attend and respond to student thinking by design. *Science Education, 99*, 863-895. https://doi.org/10.1002/sce21182

Kelly, G. J. (2014). Discourse practices in science learning and teaching. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education*. Vol. 2. (pp. 321-336). Routledge, Taylor & Francis Group, Publishers.

Lave, J. (1991). Situating learning in communities of practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 63-82). American Psychological Association. https://doi.org/10.1037/10096-003

Levin, D. M., Hammer D., & Coffey, J. E. (2009). Novice teachers' attention to student thinking. *Journal of Teacher Education, 60*, 142-154. https://doi.org/10.1177/0022487108330245

Lottero-Perdue, P. S., Masters, H. L., Mikeska, J. N., Thompson, M., Park Rogers, M., & Cross Francis, D. (2024). Elementary preservice teachers' responsiveness while eliciting students' initial arguments and encouraging critique in online simulated argumentation discussions. *Science Education, 108*, 546–580. https://doi.org/10.1002/sce.21847

Luna, M. J. (2018). What does it mean to notice my students' ideas in science today?: An investigation of elementary teachers' practice of noticing their students' thinking in science. *Cognition and Instruction*, *36*(4), 297–329. https://doi.org/10.1080/07370008.2018.1496919

Mehan, H. (1979). *Learning lessons: Social organization in the classroom*. Harvard University Press.

Nicol, C. (1999). Learning to teach mathematics: Questioning, listening, and responding. *Educational Studies in Mathematics, 37*, 45-66. https://www.jstor.org/stable/3482682

Rosebery, A. S., Warren, B., & Tucker-Raymond, E. (2016). Developing interpretive power in science teaching. *Journal of Research in Science Teaching*, *53*(10), 1571-1600.

Russ, R. S., & Luna, M. J. (2013). Inferring teacher epistemological framing from local patterns in teacher noticing. *Journal of Research in Science Teaching, 50*(3), 284-314.

Sherin, M. G. (2001). Developing a professional vision of classroom events. In T. Wood, B. S. Nelson, & J. Warfield (Eds.), *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 75-93). Erlbaum.

Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 383-395). Erlbaum.

Sherin, M. G., Jacobs, V. R., & Philipp, R. A. (Eds.) (2011). *Mathematics Teacher Noticing: Seeing Through Teachers' Eyes*. Taylor & Francis.

Sherin, M.G., & van Es, E. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education, 13*(3), 475-491. https://www.learntechlib.org/primary/p/4824/

Sherin, M. G., & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education, 60*, 20-37. https://doi.org/10.1177/0022487108328155

Talanquer, V., Tomanek, D., & Novodvorsky, I. (2013). Assessing students' understanding of inquiry: What do prospective science teachers notice? *Journal of Research in Science Teaching, 50*, 189-208. https://doi.org/10.1002/tea.21074

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. https://www.learntechlib.org/primary/p/9171

van Es, E. A., & Sherin, M. G. (2006). How different video club designs support teachers in "learning to notice." *Journal of Computing in Teacher Education, 24*, 244-276. https://doi.org/10.1080/10402454

Windschitl, M., Thompson, J. J., & Braaten, M. L. (2018). *Ambitious science teaching.* Harvard Education Press.

Wood, T. (1998). Alternative patterns of communication in mathematics classes: Funneling or focusing? In H. Steinbring, M. G. Bartolini Bussi, & A. Sierpinska (Eds.), *Language and Communication in the Mathematics Classroom* (pp. 167-178). National Council of Teachers of Mathematics.

Yin, R. K. (2009). *Case study research: design and methods* (4th ed.). Sage Publications.

Zangori, L., Snider, R. B., Morge, S., Park Rogers, M., Hargrove, T. Hermann, R. S., & Howell, H. (2025). Orientations-in-Practice: Mathematics and Science Preservice Secondary Teachers Learning to Orchestrate Discussions. *School Science and Mathematics*, 1-16. https://doi.org/10.1111/ssm.18342

Appendix

Examples of Episodes Used with the Development of Decision Tree Main and Smaller Branches.

Branches	Dialogue Examples
FOCUSING	
Teacher asks student to elaborate on their response by explaining their reasoning for that response.	T1: …Did anybody else try using paper besides lined? S: We tried to use tissue, but it didn't work. T2: It didn't work? Why don't you think it worked? S: Because it was way too thin.
Teacher asks student to provide a different example of their idea (application).	T1: Can somebody give an example of what it means when something is two dimensions or something is three dimensions? S1: 2-D is flat and three D actually like pops out. T1: Okay T2: Does that make sense? Like somebody give me an example of something that's 3-D? S2: Ms. Young's desk. T1: What about 2-D? S1: Paper
Teacher uses student idea to "shift the flow" of the lesson to explore the idea further.	S1: Um, some are different and not all the same color. T: And that's OK because right here we are sorting them by size. But could you sort them by color too? S1: *Nods to indicate yes.* T: You could? How would you do that?

Branches	Dialogue Examples
	S1: You would see if they are the same color. T: OK, so maybe if you had three oranges ones you'd put them here. S1: *Nods to indicate yes.* T: If you had two green ones you would put them in a different pile.
FUNNELING	
Teacher uses student's responses to bridge to next concept with the goal of leading student to an intended answer	T: An ice cube. So we'd have ice cubes in here, they would be a solid. What did we just do? We changed a liquid into a… S1: Solid? T: Solid. OK, and then if I'm like, well, I'm tired of these ice cubes…I'm going to dump them out, we're all gonna go to recess, then when we come back…what would happen to our ice cubes? S1: They would turn into water. T: They would turn in to water. Which one did we say water was? S1: A liquid. T: A liquid. So, we would have essentially a puddle of water, right? (Doesn't wait for student responses.) OK…so our state changes that we're talking about, they are from a liquid to a solid and a solid to a liquid. So, I just gave you the example of turning water into ice and then turning the ice back into water.
Teacher initiates follow-up with an open-ended question, but after no student response follows with a closed question.	T: Okay, now let's talk about item A. What did you guys notice about that? S1: It is a lotion. T: How did you know it was a lotion? S1: It smells like it and feels like it. T: It smells like lotion and feels like lotion? Okay, We will now talk about matter. What is a lotion? S2: It is solid. T: She thinks it is a solid. What is everybody else thinking? S3: Liquid T: He thinks it is liquid. Why do you think it is liquid? S3: It moves. T: Alex says lotion is movable. That is very good. What else about lotion makes it liquid or solid? If you think it is a liquid raise your hands. Do you think it is a solid?
Teacher asks open questions to review concepts previously experienced.	T: OK boys and girls, who can tell me what we worked with last week? S1 : Fabric. T: Fabric. What did we use with the fabric? S2: Um, we heard the sounds we hear. T: The sounds with fabric. What else? S3: We used our five senses. T: Our five senses, good. Can you guys remind me what the five senses are? S4: We didn't use one of them. T: Which one didn't we use? S4: Eat. T: Eat. Our sense of taste *(points to her mouth)*. We don't want to taste the fabric. S (all): *Laughing and making yuck sounds.*

Branches	Dialogue Examples
	T: So which ones did you use? S5: Uh…see, uh hearing. T: Our hearing, OK. S6: Our sense of touch. T: Our sense of touch. Our sense of hearing. [*Holds up 2 fingers to keep track*]. S7: Our sense of smell. T: Smell and S8: Our sense of see. T: Sight. OK, that's four. And we didn't use taste, right? S2: No.
Teacher asks questions to model for student how to think through an activity.	T1: So who would like to help me sort these into two piles? Do you want to come up here. How could we sort all these fabrics into two piles? T2: What's one sense that you could use to sort them? S1: Feel T1: Okay, how does it feel – if you look at the word wall – soft, smooth, bumpy, hard? S1: It feels bumpy. T1: Bumpy. Okay do any of the others feel bumpy? Does that one feel bumpy? S1: Nods head T1: Any others? S1: Student shakes head. T1: No okay so we can sort these into one pile. Does someone want to come up and make a second pile? T2: So instead of bumpy what kind of feeling do you want to use? S2: These are soft. T1: So these three feel soft.
ACKNOWLEDGING	
Teacher gives a generic follow-up comment of "Ok" or "Thanks" and moves to another student.	T: Okay can anybody, just in case anybody else in the class might not know, can anybody tell me what it means to make a prediction? Does anybody remember what a prediction is? S: Umm it's when you make a prediction it's not a right or wrong answer. T: Okay so prediction is when you think prior to actually acting out your investigation. So last week we actually made predictions about what would happen if water was put onto those fabrics and some people said they were going to stay on top, some said they were going to go through, but when we actually went to the tables and did the activity we were able to come up to the front and fill out our chart and put what happened when the water was put on the fabrics. And this week we are going to do the same thing.
Teacher responds to correct student thinking.	T: In your journals, can you write something else that you think has gas in it? S: Basketball T: A basketball. That is right. It has gas in it.

Branches	Dialogue Examples
Teacher asks student to repeat or rephrase response to ensure peers heard comment.	T: What do we hear? What are some things that we can hear? S2: Umm pop stuff. T: (leans forward to student) You can hear what? S2: (repeats) Pop stuff T: Things that pop. Yeah, things that might pop.
Teacher responds with a comment to offer positive encouragement but not a substantive connection to student's shared idea.	T: Yeah did you have one to share? S: Yep. T: Okay can you tell us about it? S: This one has colors all over the place. T: So this one has lots of colors. S: And then light ones. T: So these are light colors for his second pile. And what's your third one? S: Dark colors T: And this one was a dark color.
NO RESPONSE	
Teacher ignores student response by asking a new or unrelated question to class.	T: Let's say my Dad is architect and needs to build a structure between 2 cities, but there is a river between them. Is there any type of structure that you think would work well? S1: An arc? T: An arc. Ok. What would an arc do? S2: It's just like a little rainbow T: Now I want cars to be able to travel from city to city
Teacher ignores student response and follows with the idea the teacher was looking for.	T: We already used sight and we already used feel so what sense do we still need to use? S: I'm not going to taste. T: So we didn't use our hearing. S1: Got it. T: Okay how did you do it? S: Explaining (can't hear). T: Okay but shat sense have we used? We've used touch, we used sight, so let's try to listen. What did you say? What did you say this sounded like? S1: It sounds like sand. T: So could we put all fabrics that sound like sand together. S1: None of them sound like sand. T: Can we put them in three groups? S1: Explains her three piles.
Teacher asks rhetorical question with no intention of receiving a student response.	T: Ok, if you could- you can't really see DNA with your hands, like if you held it out in front of you, it would be really tiny, you couldn't see it. Do you think it would be easy to learn from that if you can't see it? Like, the real-life thing? It would be hard to learn from.

Note: Each row is a separate episode coded from across all 15 videos. S = student; T = Teacher. Students and teachers change from row to row, providing representation of all three grades and pre-service teaching teams.