J Math Teacher Educ (2018) 21:5–34
https://doi.org/10.1007/s10857-016-9347-x

Audible conversational affordances and constraints of verbalizing professional noticing during prospective teacher lesson study

Julie M. Amador[1] · **Ingrid S. Carter**[2]

Published online: 13 April 2016
© Springer Science+Business Media Dordrecht 2016

Abstract Lesson Study, which assumes multiple variations, is a collaborative method that provides an opportunity for teachers to notice professionally. We analyzed how audible conversational components afforded and constrained the verbalization of professional noticing of a lesson study team. The team, comprised of six prospective teachers, a classroom teacher, and a university facilitator, participated in weekly lesson study cycles in a teacher education program. Results indicate that a structured lesson study process afforded professional noticing as participants attended to and analyzed students' thinking. However, noticing was constrained by shifts in the conversation content and lengthy segments of individuals exerting expertise. Findings indicate that the facilitator played a crucial role in increasing the incidence of professional noticing and also contributed to the decline of noticing. Implications for teacher education programs are included.

Keywords Lesson study · Professional noticing · Prospective teacher education · Field experience

Introduction

Preparing elementary teachers to include effective pedagogical practices in the mathematics classroom to support students' mathematical learning is a continual focus for teacher educators as they implement new models and methods to increase prospective teachers' competency (Drake et al. 2014; Roth McDuffie et al. 2014). Some teacher educators have focused on the role of curricular materials and have emphasized the

✉ Julie M. Amador
jamador@uidaho.edu

[1] University of Idaho, 1031 N. Academic Way, Coeur d'Alene, ID 83814, USA

[2] Metropolitan State University of Denver, Campus Box 21, P.O. Box 173362, Denver, CO 80217-3362, USA

educative components of resources (Drake et al. 2014); others have incorporated technology through video reflections with specific questions for prospective teachers focused on multiple mathematical knowledge bases (Roth McDuffie et al. 2014). These recent efforts have restructured elementary teacher preparation courses around the notion of professional noticing of children's mathematical thinking (Jacobs et al. 2010; van Es 2011; van Es and Sherin 2008), which involves observation and analysis of what students say and do in order to tailor instruction to students' needs. Building on this work, we were interested in understanding how Lesson Study, as a tool for restructuring a teacher preparation course, provides opportunities for professional noticing of students' mathematical thinking.

Recent research has found that attending to students' thinking through professional noticing can increase the pedagogical and content knowledge of practicing and prospective teachers (Jacobs et al. 2010; Mason 2002; Philipp et al. 2007). When teachers give their full attention through attending, analyzing, and responding to students' thinking, they are able to conceptualize students' understandings (Mason 2002; Norton and McCloskey 2008; Steffe and Thompson 2000; Weiland et al. 2014). Franke et al. (2001) studied teachers participating in a professional development program that emphasized understanding students' thinking and found these teachers considered students' cognition as central, held detailed knowledge about how students were thinking, characterized developments in thinking, and sought collaborative opportunities to discuss students' thinking.

Lesson Study, which assumes various formats depending on context, is one collaborative professional development method that provides an opportunity for teachers to notice professionally as they focus on students' thinking in reflective discussions—note that we use Lesson Study to refer to the Japanese version or related researched versions of the process and lesson study to reference our work (Chichibu and Kihara 2013; Murata et al. 2012; Shimizu 2002). Lesson Study is a cyclical process in which teachers investigate a problem, set a goal, plan a lesson to address the problem, analyze the teaching of the lesson, and meet reflectively following the lesson to consider what could have been improved with respect to students' thinking; however, this process varies depending on culture (Fernandez 2002; Lewis et al. 2009). Participants then focus on students' thinking as they engage in multiple repetitions of this cycle, meaning that at any point in the process the emphasis is on student learning and the connection between teaching and learning (Murata 2011). From engagement in the entire professional process, teachers gain pedagogical and content knowledge, often shifting in their beliefs about effective teaching, becoming members of a professional community, and becoming familiarized with teaching–learning resources (Lewis et al. 2009). An important component for professional growth within Lesson Study is the reflective meetings that are a part of each cycle and occur following the teaching of the lesson; we refer to these meetings as *lesson study analysis meetings*. Specifically, the lesson study analysis meetings provide a context for the discussion of student thinking and the occurrence of noticing. We were therefore interested in understanding the affordances and constraints for professional noticing within a lesson study analysis cycle to further highlight how the context of lesson study may influence the verbalization of professional noticing within our goals and aims. The intent was to build on the current research focused on restructuring elementary mathematics teacher preparation courses through an analysis of the role of Lesson Study as a tool for supporting prospective teacher development. This work focuses on one component of the larger lesson study cycle that has been embedded as a restructuring component of a mathematics field experience course in a teacher education program.

Theoretical framework and relevant literature

This article is theoretically framed with the construct of professional noticing as a way to understand the methodological integration of Lesson Study in a prospective teacher context. The following describes the construct of professional noticing and makes a case for theoretical connections to Lesson Study, based on previous literature.

Professional noticing

When teachers notice professionally, they are metacognitive about where they focus their attention and their perception of classroom events (Mason 2002, 2011). Building on the work of Mason (2002), we postulate that teachers attend to student thinking to identify classroom instances that are most pertinent for improving instruction. This focus is imperative to designing and implementing instruction based on the thinking and reasoning of students, and finding ways to meet the needs of learners with various levels of understanding. Efficacious professional noticing includes the ability to attend to student thinking while implementing a lesson or reflecting on a lesson, to routinely analyze student thinking and to efficiently identify situations that require intervention (Miller 2011).

The roots of professional noticing are grounded in professional vision (Colestock and Sherin 2009; Mason 2002; Sherin and van Es 2005), which include observing and interpreting events in the classroom. Professional noticing builds on this concept as a process by which teachers make sense of what occurs during instruction and make plans to respond to what students are doing (Sherin et al. 2011). In their *Learning to Notice Framework*, van Es and Sherin (2002) define three aspects of professional noticing: (a) identifying what is important in a teaching situation, (b) using what is known about the context to reason about the situation, and (c) making connections between specific events and broader principles of teaching and learning. More recently, Jacobs et al. (2010) suggested that professional noticing of children's mathematical thinking also includes interpreting students' thinking and deciding how to respond. For the purposes of this article, we consider the term *noticing* to include: (a) attending to student thinking, (b) interpreting student thinking, and (c) deciding how to respond based on the analysis of student thinking or with a connection to broader principles of teaching and learning. Additional research has suggested that developing the ability to notice can be learned through scaffolded support and collaboration (e.g., Roth McDuffie et al. 2014; Star et al. 2011).

Roth McDuffie et al. (2014) note that teachers' noticing supports students' mathematical knowledge development in deep and meaningful ways. In their recent work, they restructured components of an elementary (K-8) teacher preparation course to include a video analysis activity to engage prospective teachers in the approximation of the practice of noticing. Findings indicated that prompts and the structure of the activity supported the development of noticing among prospective teachers by increasing the depth of noticing and their focus while noticing. In related work with prospective teachers watching a video lesson, Star and Strickland (2008) found that prospective teachers developed the skill of noticing, but noted that this analysis did not occur from the context of their own teaching. Furthermore, in a study using video in a microteaching context, Roller (2015) focused on identifying important aspects of teaching and making connections to broader educational principles (van Es and Sherin 2002), during which prospective teachers were acting as K-12 students. Her work was based on the suggestion that the lack of interaction with students in the preservice context may limit prospective teachers' abilities to "reason about

the situation" (van Es and Sherin 2002, p. 574). She found that prospective teachers benefitted from reflecting though repeated views of lesson video and recommended that, for the sake of accuracy, reflecting without video should occur immediately after teaching. The present study draws greatly on this work analyzing prospective teachers' noticing using video (i.e., Roth McDuffie et al. 2014; Star and Strickland 2008); however, our work augments this literature on the basis of context, situating prospective teachers in authentic teaching situations through the use of lesson study. Given this, it was important to further investigate how prospective teachers notice when they engage in iterations of observing live teaching through the lesson study cycle, during which they immediately reflected and then planned consecutive lessons based on their authentic interactions with elementary school students. These immediate collaborative reflections and consecutive lessons allowed prospective teachers to implement the changes they suggested in the next lesson. Thus, we situate Lesson Study within the theoretical framing of noticing as a context within which the affordances and constraints of noticing can be analyzed.

Lesson study as a context for noticing

To embark on this research, we were specifically focused on the affordances and constraints of Lesson Study for promoting the verbalization of noticing among prospective teachers. We recognize that the format and structure for Lesson Study varies depending on context. Lesson Study has been a professional development practice in Japan, where variations of the process are common (Chichibu and Kihara 2013; Shimizu 2002); however, recent emphasis on increased professional learning opportunities in other countries has led to the expansion of the professional practice in the United States of America (Lewis et al. 2009; Perry and Lewis 2009; Stigler and Heibert 1999). As Lesson Study has been adapted globally, the context of practicing lesson study with practicing teachers has begun to include prospective teachers (Fernandez 2010; Fernandez and Zilliox 2011; Marble 2007). For example, Fernandez and Zilliox (2011) found that Lesson Study supported prospective teachers' increased understandings about effective mathematics teaching and the "cooperation and negotiation" that occurred through Lesson Study encouraged a focus on students' mathematical learning (p. 97). Similarly, Murata and Pothen (2011) found that, "In lesson study, prospective teachers deepen their understanding of mathematics content through investigating student learning of the content" (p. 111). Both studies incorporated a focus on prospective teachers analyzing students' learning, suggesting that Lesson Study can provide a rich context for professional noticing of students' mathematical thinking. However, neither study focused specifically on what prospective teachers notice about students' mathematical understanding nor specifically on how the Lesson Study context, including participants' interactions, affords and constrains this focus.

Infusing methods, such as Lesson Study, into a teacher education program is not a novel concept; however, the intertwining of noticing of students' mathematical thinking as a theoretical construct supporting the Lesson Study process is an innovate notion. In prior research, Lesson Study in teacher education programs was often encouraged with a focus on prospective teachers' attention on students' thinking (Marble 2007); however, as prospective teachers engage in this process, what they notice about how students think depends on their orientation toward the lesson being taught (Murata 2011; Roth McDuffie et al. 2014; Star and Strickland 2008). Murata (2011) points out that noticing does not necessarily occur naturally for prospective teachers and is difficult to accomplish in artificial teaching settings (e.g., microteaching, video), thus calling for more authentic experiences.

Although there are variations of Lesson Study, the process for practicing teachers typically occurs in a more authentic context (as compared to practices such as microteaching or video) and provides the structure that affords opportunities for participants with varying backgrounds to notice different components from the lesson and formulate connections between what is noticed and their knowledge of learning and teaching (Chichibu and Kihara 2013; Mason 2002; Murata 2011). In these contexts, the support of knowledgeable others is critical to Lesson Study process, but these experts are not always present (Yoshida and Jackson 2011). Knowledgeable others are "knowledgeable about subject matter content or pedagogy, but also experienced observers and discussants of classroom instruction and student learning" (Yoshida and Jackson 2011, p. 286). In the current study, the knowledgeable others in the lesson study model were a university facilitator and a classroom teacher, who represent content and pedagogical content knowledge expertise, as well as practitioner knowledge. The facilitator in this study played a particularly crucial role in supporting the lesson study process and was likely considered an expert to other participants in light of her involvement in the larger research project. This context differs from other formats of Lesson Study, which commonly includes practicing teachers with content experts as knowledgeable others (Yoshida and Jackson 2011). Further, the conversational components in Lesson Study often differ by participant type and the inclusion of knowledgeable others as experts during the process is essential for prospective teacher growth (Amador and Weiland 2015; Corcoran 2011; Yoshida and Jackson 2011). We recognized that the inclusion of these knowledgeable others as members of the lesson study process may influence the noticing of the prospective teachers and was interested in exploring the juncture between lesson study, noticing, prospective teachers, and knowledgeable others.

Therefore, we were interested in answering: What audible conversational components during lesson study support noticing of students' mathematical thinking? What audible conversational components during lesson study result in the decline of noticing of students' mathematical thinking? In this case, we define audible conversational components as spoken interactions performed by lesson study team members. We recognize that the study is limited to analysis of participants' verbalized noticing and interactions; therefore, we sought to understand how audible conversation components afforded and constrained the verbalization of professional noticing.

Methods

The study focused on the use of a modified version of Lesson Study (explained in detail in Weiland et al. under review) with elementary prospective teachers as a component of a field experience course focused on improving prospective teachers' understandings of students' mathematical and scientific knowledge. The field experience course took place during one fifteen-week semester at a university in the Midwestern portion of the USA. We utilized an instrumental case study (Stake 1995) to highlight noticing in lesson study and focused on one bounded case (one lesson study team) to illustrate this issue (Creswell 2013; Yin 2009). To do this, we studied the first seven weeks of a field experience course, which focused on the content area of mathematics and did not include data from the second portion of the semester, which focused on science. The purpose of this selection was to examine the lesson study sessions addressing students' mathematical understanding without the introduction or discussion of multiple content areas. Recognizing there is not one single method called Lesson Study, prospective teachers took part in seven consecutive

weekly cycles of a modified version of mathematics lesson study as a component of the field experience.

Participants

Twenty-four prospective teachers were enrolled in the field experience course and were divided into four lesson study teams, with six prospective teachers in each team; all teams followed the same lesson study process, but in different classrooms within the selected school. All prospective teachers had taken three mathematics courses: Number and Operations, Finite Mathematics, and Geometry and Measurement, and had participated in field placements in other content disciplines, but had not taken part in any type of lesson study process. During the semester of study, prior to taking part in the lesson study process, all prospective teachers spent six hours of class time learning about the process and related skills and becoming orientated with Lesson Study. They completed readings related to Lesson Study outside of class time. Participants specific to this study included one lesson study team, comprised of six prospective teachers, one classroom teacher, and a university facilitator who taught the field experience course. The reason to focus on one team was purposeful because it was a bounded system (Stake 1995). All six prospective teachers were placed in the classroom of a first-grade teacher, were in their third year of a teacher education program, and were concurrently enrolled in a mathematics methods course. The prospective teachers were all female and ranged in age from 19 to 22, which was representative of those in the teacher education program at the institution where the research took place.

The knowledgeable others in the process included a university facilitator and a classroom teacher. The university facilitator, a former middle school teacher for six years and mathematics coach for three years, was a doctoral student in mathematics education and was the instructor of record, teaching the course for the first time. She held a bachelor's degree in mathematics and had taken part in a 3-day professional development program on Lesson Study and the use of the method in the field experience course to improve her own knowledge and abilities. The classroom teacher was in her second year of supporting prospective teachers to use lesson study and had been teaching elementary school for more than 20 years. She had hosted field experience and student teachers routinely for years, prior to taking part in the lesson study component of the field experience. She had some prior knowledge of the lesson study process and attended a 1-day professional development training on lesson study annually. The facilitator and classroom teacher's roles as knowledgeable others were similar in that they were to support the prospective teachers throughout the entire lesson study process, sharing their content and pedagogical knowledge; both provided feedback on all stages of the process. It should be noted that the course was graded by the university facilitator as pass/fail, and prospective teachers were evaluated based on their participation in the lesson study analysis meetings, not on the content of their comments. At the time of data collection, the authors of this article were a university employee and a university student researching the process, but were not actively involved in any components of the lesson study process.

Lesson study context

The lesson study cycle consisted of weekly interactions among the lesson study team participants and focused on planning, implementing, and reflecting on lessons. The six prospective teachers placed in the classroom were divided into pairs and worked in these pairs throughout the semester. The setting was authentic in that the classroom was a

functioning full-time educational setting; however, it should be noted that the prospective teachers were guest teachers in the classroom. Each week, one of the three pairs of prospective teachers was responsible for teaching a whole-class mathematics lesson to the entire first-grade class; the other two pairs, the classroom teacher, and the facilitator participated in the lesson study process as observers and assisted when the teaching pair requested. To initiate the first lesson study cycle during the semester, the prospective teachers and facilitator observed the classroom teacher enact a mathematics lesson with her class. During this time, the observers took field notes as they watched the lesson and completed a Lesson Observation Form (see "Appendix") that asked them specifically about students' mathematical thinking and requested evidence from field notes be used for supporting claims about students' mathematical thinking. This form was a scaffold to support prospective teachers' as they attended to, interpreted, and responded to students' thinking. Following the initial teaching and observation, the lesson study team met to reflect on the lesson and provided comments about student thinking during the lesson study analysis meeting. Prospective teachers were asked to refer to their Lesson Observation Forms to guide their discussion. Then, the entire team planned the next lesson that would be taught in the same first-grade classroom the following week. The prospective teachers did not reteach the lesson (because they were working with the same class each week), but used the information gathered during the lesson study cycle to revise their original lesson plan and to inform considerations about the next lesson in the unit. Thus, during the planning phase prospective teachers were expected to focus on responding to students' thinking, based on their observations (attending) and interpretations of students' thinking from the previous lesson(s). In each of the subsequent six weeks, one pair of prospective teachers (on rotation) was responsible for the teaching component of the lesson study cycle. One complete cycle included: (1) a lesson study team meeting to plan the lesson that would be taught, study curriculum, and set a goal for the instruction, (2) the teaching of the lesson by the designated prospective teaching pair, (3) observation by all other members of the lesson study team during which they took detailed field notes (with an emphasis on students' mathematical thinking), and (4) a lesson study analysis meeting following the teaching to consider revisions to the lesson that would improve student learning, reflect on the process, and plan the next lesson. The prospective teachers were required and expected to participate in each component of this cycle on a weekly basis; this included studying curriculum, planning the lessons, teaching lessons, taking field notes, observing, completing the Lesson Observation Form, and actively participating in the lesson study analysis meetings. This cyclical process repeated seven times throughout the semester with mathematics content, with the classroom teacher enacting the first lesson and the three pairs of prospective teachers each teaching two lessons on a rotating cycle.

Lesson study analysis meeting

The lesson study analysis meetings, which were one component of the lesson study cycle, involved the entire lesson study team (six prospective teachers, facilitator, classroom teacher) and typically lasted 30–60 min following each lesson. The format for these meetings was designed specifically for the context, given constraints of the amount of time allocated for a university class. All participants were given a course-specific protocol outlining the format of these meetings, which was based on Lesson Study research (Fernandez 2002, 2010) and modified by the project team based on past implementation results, which included feedback from former university facilitators, involved classroom teachers, and prospective teachers. This type of configuration is similar to the structure provided to prospective teachers in research focused on

restructuring a teacher preparation course with an emphasis on noticing (Roth McDuffie et al. 2014). The protocol included the following: (1) After observing the enacted lesson and prior to meeting for the lesson study analysis meeting, the facilitator encouraged all participants to reflect on the teaching and record at least two specific examples of student thinking on the Lesson Observation Form, with supporting evidence from field notes—they were guided by specific questions about students' thinking. They also recorded two specific suggestions to improve students' thinking based on evidence they recorded while observing the lesson. Participants then had these written reflections available as a reference during the lesson study analysis meeting. (2) At the start of the meeting, the facilitator prompted the participants to reflect on the lesson by considering what went well and what did not go with respect to students' thinking and in connection to current research of effective mathematics teaching. At which point, the two prospective teachers who taught the lesson responded first, followed by the other prospective teachers in the group who consulted their notes. (3) After all prospective teachers had responded to the prompt, the classroom teacher and the facilitator responded. (4) After all participants shared their reflections, the facilitator encouraged discussion on improvements that could have been made to the lesson and these were recorded. (5) The facilitator then encouraged the group to study the curriculum and plan the next lesson (the prospective teachers were expected to have studied the curriculum in pairs before coming to this meeting as well). Participants were encouraged to use data from their field notes when making decisions about lesson revisions and what should be taught next.

Lesson study modifications

The lesson study format described was designed specifically for use with prospective teachers based on the constraint that the field experience course met on a weekly basis for a three hour time period. In the modified version, participants considered a goal for student learning and development, planned a research based lesson, observed the lesson while collecting data, used the data to reflect on the lesson and instruction, and revised the lesson—all similar to Murata's (2011) description of Lesson Study. The main differences were: (a) The amount of time spent studying curriculum to plan the research lesson was split between time with the lesson study team and the pair of prospective teachers who were teaching the lesson; the pair typically spent a considerable amount of time on this process (likely multiple hours), while the whole-group time for this was limited (approximately 15 min), (b) the protocol that was followed during the lesson study analysis meetings differed from Lesson Study formats, (c) the function of the knowledgeable other differed in that they facilitated the lesson study analysis meetings and not all lesson study processes include a knowledgeable other (Shimizu 2002), and (d) after teaching, the lesson was revised by the group and this was recorded on paper, but the same lesson was never retaught in a different classroom; instead, the prospective teachers considered these revisions as they planned a lesson on a new topic. However, we note that Fujii (2014) clarifies that reteaching a lesson is not absolute within the organic process of Lesson Study, so some may not consider this to be a difference.

We assert that a model similar to the one described is necessary for prospective teachers because of the limited number of institutional hours that are typically a component of a teacher education course and because of the prospective teachers' limited instructional knowledge bases. First, by working in pairs outside of the lesson study analysis meeting context, the prospective teachers were still able to study curriculum and plan the lesson. We recognize that having multiple meetings or extended hours for planning as a group through *kyozaikenkyu* (instructional material investigation) would be ideal, but

modifications had to be made because of the constraints imposed by the university prospective teacher program, which would be typical at other higher education institutions (Yoshida and Jackson 2011). Second, prospective teachers lack knowledge and experience with participating in conversations similar to the lesson study analysis meetings that specifically focus on students' mathematical understandings (Star and Strickland 2008). As a result, the structured protocol for the lesson study analysis meetings, as well as the Lesson Observation Form, was implemented to provide prospective teachers with a basis for their discussion and to scaffold their focus on noticing students' thinking. Likewise, the knowledgeable others assumed more of a leadership role in the discussions as opposed to Lesson Study (Corcoran 2011). However, the background knowledge of these experts was similar to descriptions provided by Yoshida and Jackson (2011), in that they were experienced teachers, knowledgeable about subject matter content and pedagogy, and experienced observers of lessons, but they learned about lesson study through professional development, not participation (Watanabe 2011). Therefore, we argue that this model closely mirrors Lesson Study (Murata 2011), given the constraints of a prospective teacher program.

Data collection and analysis

Data for this study came from seven lesson study cycles bounded within time and place, which were considered the bounded system for the case study analysis (Creswell 2013; Stake 2005; Yin 2009). Specifically, data include video recordings of the weekly lesson study analysis meetings that took place following the lessons and the corresponding transcripts. These data were adequate given the focus of this article on the conversational affordances and constraints of lesson study as related to noticing; the data collected in this bounded system were purposeful for answering the research questions (Creswell 2013). The purpose of data analysis was twofold. First, we were interested in identifying the instances of noticing that took place in the dialog during the lesson study analysis meetings to gain an in-depth understanding of the occurrence of noticing (Creswell 2013; Yin 2009). Second, we were interested in understanding how the structure of the meetings afforded and constrained these instances of noticing. This resulted in three phases of data analysis, with Phase One and Phase Two described in detail in Amador and Weiland (2015). Therefore, the following briefly describes these two phases and emphasizes Phase Three analysis.

Phase One and Phase Two

In Phase One, we (both authors) began by open coding for the types of responses in the conversation, without focusing on the content of the conversation (Corbin and Strauss 2008). Initially, data were read in their entirety and response types were determined based on grounded theory (Glaser and Strauss 1967). After creating a framework for analysis, segments of the transcripts were analyzed by talk turn ($n = 809$) to identify the type of response: (a) facilitation, (b) contribution, or (c) noticing (see Table 1, column 1). A talk turn was defined by a change in speaker. Inter-rater reliability was 91 % during Phase One analysis, and all discrepancies were reconciled. In Phase Two, we analyzed the structure of the conversation and focused on the context for the occurrence of noticing in the data set. To do this, we further analyzed all Phase One data coded as *noticing* ($n = 282$ talk turns coded as noticing) as (1) attend, (2) interpret, or (3) decide how to respond (Jacobs et al. 2010; see Table 1, column 2) and then analyzed the

Table 1 Process of generating phase three themes with examples of codes for each phase

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Facilitator: Overall then what did you notice about the students' thinking? Are they getting it, are they kind of getting it? Are there any like common misconceptions that some of them are having? **(Facilitation)**		**Initiate response:** Response is because of initiated prompt	Noticing after facilitator prompts	**Facilitator-initiated prompts (affordance)**
Prospective Teacher 5: From what I saw they were getting the numbers. I saw them understanding most of it like when you guys were explaining but I was going between the other three mostly. I didn't, I noticed **(Noticing)**	**Interpret**		Noticing is a mix of attending and suggesting, [and] noticing following prompt	
Prospective Teacher 6: Yeah I think there are still some that are confused which is, you know, normal and then there are some that are way beyond this that you don't, it's totally they're totally over number, but I think for the most part, kids are getting it and the groups that were kind of, you know, the median, like middle groups, I think, you know these lessons were pretty good for them **(Noticing)**	**Interpret**			
Facilitator: So now taking what we actually just saw today, what are some evidences of students' thinking? You can either say specific people or maybe generalities **(Directive)**		**Protocol prompt:** Response is because of directive based on lesson study protocol (one component was to discuss what occurred with evidence of student thinking)	Prompt followed by responses, with everyone having a turn to respond; inclusion of noticing, emphasis on each person having an opportunity to speak	**Turn-taking following prompts (affordance)**

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Prospective Teacher 6: Well, I was working with Adam and he likes to use the block, so he'll see thirteen and he'll take all the blocks and put them into piles. And he always coordinates them and gets organized with his numbers first, like colors or whatever, and then he kind of goes back to his page and does like thirteen **(Noticing)**	**Attend**			
Facilitator: So manipulatives are still very important to him with the concepts of counting **(Contribution)**				
Teacher: And he's very smart which is… Right now… He's a really gifted student **(Contribution)**				
Prospective Teacher 4: A lot of the students had… Well Kaitlyn, she had trouble realizing what that one and three together means thirteen. I don't know exactly how to say what her thinking is on that but she hasn't, she hasn't understood that those numbers represent the number thirteen. She's… One and three are two separate things to her. Putting them together is just not… Kind of hard for her to wrap her head around **(Noticing)**	**Interpret**			

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Prospective Teacher 2: I kind of already gave my example with the… I was working with Jessica and how was on thirteen but couldn't tell me she was on thirteen. So we went back and we counted up to thirteen. And then she realized, oh that's thirteen. I noticed that a lot. We [another Prospective Teacher] were just talking about it and they [students] know how to count to the number but once you just have that numbers, it's kind of a visual representation. Like difficulty even though they know how to count back to thirteen piggybacking on that. **(Noticing)**	**Attend**			
Facilitator: One thing that I noticed is that they don't understand how the decades come together yet. They can, they can count up. They, they… It's almost like they are starting to get it when they're counting rhythms, but they don't understand when we were looking at, I flipped to Anna's, nineteen. And she didn't know that that number was nineteen. And you know I, I started saying, "Well what…," I said, "Now, what number does that sound like?" She doesn't connect nineteen and nine as being similar numbers yet. So that was something I noticed. That, you know that, that'll come but they don't see that connection yet between you know like thirteen and three, fifteen and five. You know, something we take for granted **(Noticing)**	**Interpret**			

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Prospective Teacher 3: What I noticed was Kelly was writing twelve. She got the ones down. Even though there was a twelve right there for her to look like… She still was like unsure. I was like, there's a number two? I was like, just try it, just how that is there. And then she, she did it. She just took her time to figure out writing **(Noticing)**	**Attend**			
Prospective Teacher 4: I have a comment about Bray. He has very sophisticated thinking but he was on the number seventeen. He was doing little squiggles, just kind of in a zone. He did the lines. I was paying attention to him when he was going fifteen, sixteen… The number was fifteen and he counted over fifteen. He was like sixteen, seventeen and then he recognized that, you know that he went over and I said oh, "Bray, looks like you have too many," and he automatically just erased two. So he has, he's understanding subtraction at this point too which is really interesting. I didn't have to tell him that you need to take away, he jus did it automatically. So I thought that was pretty neat **(Noticing)**	**Interpret**			

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Prospective Teacher 6: I was going on with tracing maybe if you had a separate sheet with like dashes for the numbers so they can practice. Maybe they can do both sides and be able to write the number on the page as separate practice **(Noticing)**	**Decide how to respond**	**Another issue:** Referencing another issue that may not be immediate topic	Prospective Teachers engaged in various types of noticing	**Content shifts (constraint)**
Prospective Teacher 3: One thing I was thinking maybe when they went back to their desks, maybe going through one, counting one through twenty-one more time because it's seems though at the table, it's like we don't understand this! You know and to them… And then for example Quinn, she was on number twelve and she just drew one big star and I was like, oh you have to draw twelve, remember? She was like twelve and I was like, okay. I didn't know if I wanted to say, you know, draw eleven more of those because she took up the whole book with that one little star so… Now it's number thirteen, going through one through twenty again. That's about it, other than that I thought it was good **(Noticing)**	**Decide how to respond**		**(Respond: Suggestion)** and then facilitator asks a directive question **(Facilitator: Directive)** without connecting to the prior conversation or content and the pattern returns to an initiate and respond pattern to answer the question, without noticing	

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Prospective Teacher 2: Just to piggyback off Prospective Teacher 3 I was going to say that maybe in the beginning you could have like a number flashcard kind of a do, because I walked up, up to a student and she was going on to thirteen. I was like what number are you on? And she was like, I don't know. And I was like what number is this, pointing to thirteen and she was like um, I forget so we had to go back to eleven and count to thirteen and then she realized she was on thirteen so she knew by counting but she really didn't know in a visual way. And with Prospective Teacher 3, she drew a picture of a person and then she just counted all the body parts, kind of thirteen. So instead of drawing different objects, she just drew one big picture and counted thirteen things on the picture, so it was different **(Noticing)**	**Attend**			
Facilitator: Alright, how about we get the two of you to talk about things that you think could have gone better? **(Facilitation)**				

Table 1 continued

Phase one analysis (coded as facilitation, contribution, or noticing; change in speaker indicates new talk turn)	Phase Two analysis of noticing (coded as attend, interpret, or decide how to respond)	Phase Two analysis of context (see Amador and Weiland 2015 for details)	Phase Three analysis (example of memos)	Phase Three themes generated
Facilitator: And so we're, we're definitely straying from the activities and investigations, which is good, but I think we're hitting the topics. So you [looking at unit, to Prospective Teachers teaching next] might want to go through and combine ideas from three different lessons. You know how you can incorporate the tally marks, then go back to the idea of the counting jar, which appears here a couple times. I just flipped through 1.5 which is on how do I count? And that is on developing strategies for accurately counting and keeping track of quantities **(Noticing)**	**Decide how to respond**	**Asserting expertise:** Displaying own knowledge of content or pedagogy	Long series of teacher and facilitator with asserting expertise without much participation from the Prospective Teachers	**Knowledgeable others extending expertise (constraint)**
Teacher: Very hard **(Contribution)**				
Facilitator: So that should give you, not that you expect them necessarily to master that but that's something you could introduce and then maybe the week after you can reinforce that idea. Don't be afraid to have each of your lessons kind of connect and support off of each other (**Noticing)**	**Decide how to respond**			
Teacher: And also just the first step is that they know they counted wrong. That's already a triumph. So just the fact that they hesitate and they try to do something, or they do nothing means at least they're self-monitoring. And so they might not have the skill to self-correct…**(Contribution)**				

Bold indicates codes

context of the incidence of noticing, again at the talk turn level based on a framework for discussion context (see Table 1, column 3). Inter-rater reliability for Phase Two analysis was >94 %. Again, see Amador and Weiland (2015) for additional details. The following section describes the Phase Three analysis in detail, by which the research questions for this study were answered.

Phase Three: Affordances and constraints for noticing

In Phase Three, the noticing data (identified in the preceding two phases) were analyzed for patterns to identify affordances and constraints within the lesson study analysis meetings that provided for, or impeded, the development of noticing. For Phase Three analysis, we independently analyzed idea units in all transcripts for patterns when noticing occurred (Jacobs and Morita 2002). Idea units were defined as shifts in the content of conversation. Shifts were determined based on a change in the content focus of the dialog. Initially, we (both researchers) independently identified shifts in idea units for 20 % of the data. Following this, we met and reconciled differences to arrive at consensus about what would constitute an idea unit. Then, we each made these determinations for the remaining data on the basis that an idea unit changed when a participant brought up a new idea or made a suggestion that included content (mathematical or pedagogical) that was not already being discussed. For each idea unit, we examined the codes from Phases One and Two and wrote memos (Corbin and Strauss 2008) to describe what led up to the noticing, how the noticing developed in the conversation, and what led to the decline of the noticing for the given idea unit (see Table 1, column 4). These memos were theorizing write-ups of ideas about codes and relationships, through which we identified instances that afforded or constrained noticing. For example, "Long series of host teacher and facilitator conversation, with them going back and forth and asserting expertise as they talk with each other." We then met and first compared identified instances of affordances or constraints, based on these memos by going through transcripts of each lesson study analysis meeting. Specifically, we matched idea units and memos with each other and compared the content of memos, along with rationale for determining whether or not the components were affording or restraining noticing. We then noted themes of affordances and constraints in the data from the memos. We discussed these themes and then considered themes that were evident across the data set, which resulted in four: facilitator-initiated prompts, turn-taking following prompts, content shifts, and knowledgeable other extending expertise (see Table 1, column 5). Table 1 provides examples from each theme, tracing the themes back through each phase of data coding.

We intentionally do not report at the detailed level of the Phase One or Phase Two codes because those codes were analyzed within the context of the idea unit in Phase Three; the emphasis in the findings is on the themes that resulted from the three-phase analysis, not the details of the codes at each phase of data analysis. We intentionally focus on two main themes that afforded noticing and two main themes that constrained noticing because they were evident across the seven meetings—the number of affordances and constraints for reporting findings was not predetermined, but were based on analysis of the data. Other themes not reported were only evident in one or two lesson study meetings and did not influence noticing to a great enough extent to be included in the findings.

Findings

We identified two themes that supported the incidence of noticing. First, noticing occurred when the prospective teachers responded to a direct prompt from the facilitator. This occurred in seven of the seven meetings, typically two or three times each meeting. Second, the response to these prompts frequently resulted in idea units where a number of prospective teachers engaged in analyzing and attending to students' mathematical thinking, which further supported the development of noticing. This occurred in seven of the seven meetings, averaging twice each meeting. In contrast, we identified two themes in the data that resulted in the decline of noticing. Commonly, noticing declined during the meetings when a speaker shifted the content of an idea unit to begin a new topic. This occurred in seven of the seven meetings, typically once or twice each meeting. Additionally, at times the facilitator and classroom teacher engaged in extended periods of asserting their expertise as they provided suggestions with minimal input from the prospective teachers, which resulted in the decline of verbalizations of noticing from any of the participants. This occurred in seven of the seven lesson study meetings, averaging three times per meeting. No other noted affordances and constraints occurred in all seven meetings; the next most common theme was only apparent in two meetings and therefore not reported. Consequently, the themes presented are representative of the most frequent affordances and constraints across the seven lesson study analysis meetings and are not merely illustrations of rare incidences.

Audible conversational components affording noticing

The following describes two themes that were affordances for noticing: facilitator-initiated prompts and turn-taking following prompts.

Facilitator-initiated prompts

Noticing was afforded in the lesson study analysis meetings when the facilitator initiated a conversation by providing a prompt focused specifically on students' mathematical thinking. As the facilitator guided the lesson study analysis meetings, she often included prompts to encourage participants to focus deeply on students' understanding. For example, she used phrases such as "Let's focus on evidence of students' thinking" and "What were specific ways students were thinking?" Following these focused prompts, it was common for the prospective teachers to engage in conversation to answer her questions, in which they attended to students' thinking or analyzed evidence of student understanding. The following example, from a lesson study analysis meeting about a lesson on counting fruit, demonstrates a specific focused prompt, followed by a prospective teacher engaging in an expression that demonstrated noticing. The prospective teachers were prompted to talk specifically about evidence of student thinking, so one prospective teacher describes a student's use of tools, namely a number line. The italics indicate the prompt:

> Facilitator: *Alright, what are some specific ways that students were thinking that you saw, observed, as you were walking around?*
>
> Prospective Teacher 3: One thing I saw, Finley, I was looking at the worksheet, and she constantly referred to the number line [on her desk] and I thought that was, pretty neat because she's using her tools, the tools around. And like I said, I saw major, improvement with Finley, so I can tell that she's able to, able to, now being able to use tools around her without [the teacher] saying, "Hey,

> look at the number line if you get lost!" She just, mainly she can really figure out, she knows what seven fruits is and she knows the number eleven so she used the number line for the difference.

In this instance, the prospective teacher was specific about Finley's actions and how she was using the mathematical tools of a number line, to make connections between the number of apples she was counting and the symbolic representation. A similar pattern was seen throughout the seven lesson study analysis meetings.

Turn-taking following prompts

As prompts resulted in prospective teachers verbalizing their noticing, patterns of initiating and responding took place, meaning the facilitator would initiate a conversation, and the prospective teachers would respond. As this happened, the prospective teachers commonly conversed participant by participant in a turn-taking pattern, responding to the prompt. This resulted in segments that included several idea units, all from one prompt. The following provides an example of a facilitator prompt followed by responses from a number of prospective teachers. This example is intentionally lengthy to provide understanding about the pattern of initiation and response that took place while individual prospective teachers noticed within a given talk turn in this context. The lesson being discussed engaged students in reaching into a bag, retrieving objects, and then counting and recording the number of objects. Note how the prospective teachers were very specific in each discussing a different student, and even named the student, to directly address the facilitator's question. The italicized portions indicate the initiate response pattern demonstrating how the prospective teachers each responded to the facilitator's prompt:

> Facilitator: *Now let's move onto evidence of students' thinking. So what were some things you saw to either show that some students are really getting the concepts or maybe some are still struggling?*
>
> Prospective Teacher 4: I thought, *I was working with Mikayla*, and before… I'm not sure if she got the direction from or this is just what she was doing, I couldn't d, d….
>
> Prospective Teacher 1: Differentiate.
>
> Prospective Teacher 4: Yes, what she was trying to do but she would… I'd be like… She would guess that there was four and then before she would write the number four, she would actually draw like four squares, then write the number four. So I'm trying, I was trying to figure out if she heard the directions wrong or if she just… This is the way she's thinking. Does she visually have to draw it out before she's able to come up with the number? I couldn't tell which one she was doing.
>
> Facilitator: *That is very interesting.*
>
> Prospective Teacher 6: I, it was like a little bit beyond, the lesson, kind of like what you were talking about with the more than and less than. *I was working with Cole*, and he first guessed… He guessed that there was three of a particular object and then when we counted there was actually four. And so I said, would you say that that's more than, less than, or the same and he goes like it's just a little bit bigger. And I thought that that was so cool because he really understood that they were next-door neighbors on the number line, you know. And that it was bigger but not too much bigger and that was like a little bit beyond what you were going for but I thought that that definitely showed thinking.

Facilitator: *No, that is a really good example.*

Prospective Teacher 5: When *I worked with Kaden and Juan* after they got done with their stuff, we were doing some math problems. And so I asked, you know like Kaden has four squares and Juan has four squares, how many squares do you have together? And Kaden started counting but Juan just goes eight. I was like how'd you know that so quickly? He was like four plus four is eight. Awesome! So if you have four squares and Kaden has four squares and you have three triangles and Kaden has one triangle, how many do you have? And he said twelve. I was like, that was really quick! And he was like yeah because four plus four is eight, and eight plus four is twelve. And Kaden was sitting there counting still. Like it was very cool because you could see like the different ways. Because Kaden is still counting when Juan is adding in his head already.

Prospective Teacher 3: Well, um after we finished both packets, *I was with Kennedy* again, so I was okay, let me just do some…

In this extended example, the conversation began with the facilitator initiating the discussion with a prompt. Following this, the prospective teachers responded to the prompt by attending to students' mathematical thinking and analyzing how the specific students they were working with were counting and recording the objects from the bag. Note, based on the italics above, the conversation shifted from discussing one student to the next student to the next, without discussion from multiple prospective teachers about the same student's thinking. For example, Prospective Teacher 6 analyzed Cole's thinking as she discussed how he miscounted, but used this knowledge of relational understanding of numbers to make sense of the situation. Similar to Prospective Teacher 6's response, Prospective Teacher 4, Prospective Teacher 5, and Prospective Teacher 3 also provided specific input attending to children's mathematical thinking, but talked about the individual students they worked with without adding to the conversation mentioned by a fellow prospective teacher. This is notable as the extent to which each prospective teacher reported individually about noticing and the verbal talk turns did not necessarily relate to one another or build on one another. Instead, each of the aforementioned talk turns acted as an independent example of noticing. Nevertheless, the incident of noticing occurred following the prompt about students' thinking from the facilitator, indicating that the prompt afforded opportunities for the prospective teachers to verbalize their noticing.

Audible conversational components constraining noticing

The following describes two themes that constrained the verbalization of noticing: shifts in the content and knowledgeable others extending expertise.

Content shifts

The verbalization of incidences of noticing was constrained when a participant shifted the idea unit and began talking about a new topic. While an initiating prompt commonly led to the inclusion of noticing in the dialog of the lesson study analysis meetings (as noted in the previous example), noticing commonly declined when someone shifted the idea unit away from the current topic and directed the conversation toward a different content topic. This occurred as participants asked questions, included new prompts, or simply added in something that was not necessarily related to the idea unit under discussion. In the following example, the lesson being

discussed engaged students in working on tracing, writing, and counting numbers at various stations around the room. Originally, the conversation focused on students' tracing and writing numbers, and many of the prospective teachers were attending to, and beginning to interpret, students' thinking. Then, just as the prospective teachers were including more and more detail, specific to students' thinking (noticing), the facilitator asked a question that completely shifted the focus of the conversation, indicated with italics.

> Prospective Teacher 6: I was going on with tracing, maybe if you had a separate sheet with like dashes for the numbers so they can practice. Maybe they can do both sides and be able to write the number on the page, so separate practice.
>
> Prospective Teacher 3: One thing I was thinking maybe when they went back to their desks, maybe going through one, counting one through twenty-one more time because it seems… For example, Clara, she was on number twelve and she just drew one big star and I was like, "Oh you have to draw twelve, remember?" She was like, "Twelve?" and I was like, "Okay." I didn't know if I wanted to say, you know, draw eleven more of those because she took up the whole book with that one little star. So, now it's number thirteen, going through one through twenty again. That's about it, other than that I thought it was good.
>
> Prospective Teacher 2: Just to piggyback off Prospective Teacher 3, I was going to say that maybe in the beginning you could have like a number flashcard, because I walked up, up to a student and she was going on to thirteen. I was like, "What number are you on?" And she was like, "I don't know." And I was like, "What number is this?" pointing to thirteen and she was like, "Um, I forget," so we had to go back to eleven and count to thirteen and then she realized she was on thirteen so she knew by counting but she really didn't know in a visual way. And with Christine, she drew a picture of a person and then she just counted all the body parts, kind of got to thirteen. So instead of drawing different objects, she just drew one big picture and counted thirteen things on the picture, so it was different.
>
> Facilitator: *Alright, how about we get the two of you to talk about things that you think could have gone better?*

In this example, the prospective teachers began the conversation by talking about a specific student, Clara, and how she struggled with the amount of space on this article and how this could be improved. This was not specific to students' understandings, but rather focused on their writing abilities. However, as the conversation progressed, Prospective Teacher 2 began to make connections between writing numbers and numerical representations for students. In this example, she began to attend to the student's thinking and described the way Christine drew body parts to count to thirteen and needed a visual representation. Following this attending and interpreting, the facilitator interjected with a question that shifted the content of the conversation. When this occurred, the verbalized noticing that was beginning to take place with Prospective Teacher 2 stopped and the conversation was redirected to other prospective teachers who were encouraged to talk. Similar to this example, it was common that the conversations would build toward the inclusion of verbalized noticing and then someone in the group, and not always the facilitator, redirected the conversation and shifted the idea unit by asking a question or posing a different prompt to participants.

Knowledgeable others extending expertise

As the participants engaged in conversation, they verbalized their noticing as they asserted expertise and made suggestions; however, at times this assertion of expertise became a back-and-forth dialog between the classroom teacher and the facilitator, resulting in the decline of the verbalization of noticing for all participants and a drastic decline of prospective teachers verbalizing their noticing. These lengthy segments were typically solely between the facilitator and classroom teacher, in which they would each assert their expertise as they discussed what could be done in the future—one such dialog lasted over five min without any prospective teacher interjection. Thus, as the facilitator and classroom teacher provided these suggestions, the prospective teachers were verbally minimally involved. The following provides an example of the dialog between these two participants as the teacher provided input about the students, teaching, and their ability to understand and abstractly represent the number eleven. Students had been struggling with representing numbers physically, audibly hearing numbers, and writing numbers. The italics indicate instances when the facilitator and teacher were asserting their expertise:

Facilitator: But *sometimes students don't notice* what…

Teacher: You have to model, no, *you have to model it.*

Facilitator: Yeah, *students don't notice what's been there.*

Teacher: Yeah.

Facilitator: They noticed, *they noticed what's changed.*

Teacher: That's right.

Facilitator: So that was something that you could put down. Maybe review, to refer the students to their desks where they have the numbers written out. Kind of give them that little refresher.

Teacher: And it's that sort of thinking ahead to what is in your lesson plan because it's a great lesson plan. But what are the problems going to be?… And so for this one, *yeah about a third of the class knows those numbers cold and they can just do it. And then another third of the class, they're just starting to learn those numbers. And the other third, in there. And so, yeah, giving them a model of what they could do when they get stuck and really demonstrating their directions.* You know actually doing one. This is eleven; I'm going to do eleven X's. Actually physically demonstrating it. And then I think the lesson would have been clear. Because you did it verbally, but you didn't actually draw and they're not very auditive yet in kindergarten or first grade.

Prospective Teacher's 1–6: Yeah.

Teacher: And so make, *instead of having one line, just make three spaces and make it go down so they're doing one on each line so you're giving them the space in that.* And yes, I did exactly this. Yeah, *the eleven's was difficult.*

In this excerpt, the teacher and facilitator dominated the conversation by providing suggestions for future teaching. They asserted their expertise by discussing what teaching involves and made a connection between those ideas and the lesson content from the day,

which focused on representing a given quantity of items physically and writing two-digit numbers. As shown by this dialog, both the teacher and facilitator worked to assert their knowledge in a back-and-forth pattern resulting in minimal verbalization of noticing and limited prospective teacher involvement. As the knowledgeable others were talking, the prospective teachers did not insert themselves into the conversation to verbalize noticing; at the same time, the knowledgeable others were rarely verbalizing their noticing. We acknowledge that we consider this analysis on the basis of verbalizing noticing; it is possible that the prospective teachers were considering noticing during these excerpts, but did not have the opportunity to verbalize their thinking. Nevertheless, those doing the talking were not verbalizing noticing, which is indicative of the types of conversations that were occurring. This is important for recognizing that when this type of conversational pattern took hold, discussion about attending, interpreting, and responding (noticing) on the basis of students' mathematical thinking was not occurring.

Discussion and implications

The purpose of this study was to understand audible conversational affordances and constraints for noticing within a lesson study analysis meeting based on response types and discussion context determined in Phases One and Two of our analysis. We note the value of the authenticity of the lesson study analysis meetings in providing a context where participants had the opportunity to verbalize their noticing and engage in discourse about an observed lesson. The participants described students' actions and words as related to mathematics and were able to interpret actions and words to extrapolate their analysis to broader principles of teaching and learning, supported through facilitator prompting. At the same time, these instances of noticing were stifled because of audible conversational components and interactions, including shifts in the conversational content, and knowledgeable others exerting expertise over long periods of time. We recognize that the affordances and constraints discussed focus on the role of the facilitator; however, we emphasize that the intent of the research was not to focus only on knowledgeable others, but rather to understand audible affordances and constraints from all participants—the knowledgeable others, mainly the facilitator, happened to influence noticing to the greatest extent. We consider this an important finding for the consideration of teacher education programs and other contexts for lesson study. Nonetheless, we emphasize that these are the findings for this study alone and are not able to be generalized to other contexts. We also recognize that there are multiple formats of Lesson Study (Chichibu and Kihara 2013; Shimizu 2002); for the purpose of discussion, we focus on the lesson study process used in this research and discuss the affordances and constraints given our context. The following describes influences on verbalization of noticing in this study, with specific considerations about the role of knowledgeable others.

Considerations about affordances

The findings in the study point to the importance of considering the role of the facilitator in affording and constraining the noticing of prospective teachers. In understanding the affordances, we argue that prompts from the facilitator resulted in the verbalization of noticing from the prospective teachers. The questions the facilitator asked were often directly related to student thinking, which elicited responses focused on students' mathematical reasoning and thus encouraged conversations that focused on attending,

interpreting, and responding on the basis of students' thinking (Jacobs et al. 2010). These prompts were intentionally focused on provoking responses that would engage prospective teachers in thinking critically about specific models of students' mathematical thinking (Norton and McCloskey 2008). In doing so, the prospective teachers provided evidence as they described their teaching experiences and observations, which resulted in verbalizations of their noticing. They were scaffolded through the prompts to focus their attention and comments directly on students' understanding. Likewise, the knowledgeable others then responded to the prompts themselves and included evidence of student thinking to verbalize their noticing. This highlights the importance of considering prompts in a lesson study context—what are the knowledgeable others asking and how is that contributing to the outcomes of the conversation?

Second, the structure of the lesson study analysis meeting encouraged the involvement of all participants. As the facilitator would ask focused prompting questions, the prospective teachers understood that they were to respond and take part in the authentic context. Potari (2011) raises questions about group collaboration within Lesson Study and the extent to which "interactions, negotiations, and contradictions emerge" among prospective teachers (p. 131). In the structure of the current study, the expectations of the facilitator for prospective teacher involvement in the process may have influenced the interactions of the participants. Typically, as one prospective teacher would finish discussing, another prospective teacher would begin in a turn-taking pattern, without the need or interjection of the facilitator to encourage discussion. The facilitator would then add any input after the prospective teachers had all spoken. This raises questions about the extent to which this expectation encouraged collaborative discourse or stifled the free development of conversational interaction. Either way, the turn-taking pattern resulted in the verbalization of noticing, showing some promise for the structure to support conversations that include attending and interpreting students' thinking. In this case, the process of prospective teachers and knowledgeable others each sharing and participating resulted in idea units that were focused on students' mathematical thinking, and therefore resulted in noticing. Future research could explore the relationship between expectations for prospective teacher participation with lesson study analysis meetings and the influence on verbalized noticing.

Considerations about constraints

When focusing on noticing in lesson study analysis meetings, or when aiming to be specific about students' mathematical thinking, participants should consider when and how the content of a conversation should shift; this includes both prospective teachers and knowledgeable others, in this case. Specifically, there were instances in the data when a participant would ask a question or make a comment that was unrelated to the current issue being discussed, and thus initiated a content shift. This commonly led to an immediate decline in noticing. While research indicates implementing Lesson Study is a challenging process (Hart and Carriere 2011), we argue that all participants, and especially facilitators, should focus on their awareness of instances that derail noticing patterns, so they may be able to better address the questions or comments in a way that would shift the conversation back to the content that was the focus of noticing. These are instances when the subject matter expertise of the knowledgeable other (a key characteristic of these experts) becomes a necessary agent in furthering the discussion (Yoshida and Jackson 2011). Essentially, the facilitators should notice (attend, interpret, and respond) on the basis of what is happening

in the lesson study analysis meetings to afford or constrain the verbalization of noticing of students' mathematical thinking (Jacobs et al. 2010).

In addition to considering the content of the conversations, facilitators should be cognizant of their role and participation levels within the meeting. Yoshida and Jackson (2011) highlight the importance and necessity of knowledgeable others in Lesson Study and even refer to the value of these experts noting that "In English we say, 'Two heads are better than one,' and in Japanese, 'Three heads together produce Manjusri' (Buddhist enlightenment and wisdom)"; however, it is important that these experts remember they are in a position to guide and support the conversation (p. 286). Recall that when the participants were considering how to formulate future mathematics instruction based on what was noticed, the facilitator and classroom teacher often engaged in lengthy conversations asserting expertise that led to the decline of verbalization of noticing. The decline is perhaps the result of the prospective teachers not asserting themselves during the conversation, and thus they did not have the opportunity to verbalize their noticing because they were not talking. Perhaps, power relationships and interactions, as described by Corcoran (2011), were present within the group, influencing participation in the process. Considerations about participants' roles are important for ensuring a smooth nexus of power distribution to promote noticing.

As a result, it is essential that facilitators in lesson study are aware of the ways their interactions afford or constrain professional practices. This can be accomplished by focusing on the locus of awareness, marking their awareness, and making future actions based on these instances (Mason 2002). Essentially, while the facilitators are working to encourage prospective teacher noticing, it is critical that they are noticing what their students (the prospective teachers) are doing and saying and make changes accordingly (Amador and Weiland 2015). We note that prospective teachers are learning and there may be good cause for lengthy instances of asserting expertise in order to model how to notice. However, we emphasize the importance of facilitators being cognizant about these instances, being explicit about how they are modeling the act of noticing, and recognizing how this influences opportunities for prospective teachers to verbalize their noticing of students' mathematical thinking. The intent is not to indicate that teacher educators should not exert expertise, but should be cognizant of their role and contributions.

Lesson study authenticity

The authentic context (Murata 2011) of the lesson study process and lesson study analysis meetings, meaning opportunity for prospective teachers to engage in the noticing process based on live observed teaching, made way for the participants to reflect on teaching and consider what went well in the lesson and what could have been improved. Participants were able to verbalize their noticing and engage in dialog with one another about students' thinking, which supports Murata's (2011) finding that the structure of collaborative discussion in Lesson Study afforded opportunities for reflection. Takahashi (2011) reports that the varying supports provided during Lesson Study "provide teachers with opportunities to learn to really see student learning and to critically reflect on their own teaching" (p. 79). Through this structured process of lesson study, prospective teachers, the facilitator, and the classroom teacher had the opportunity to reflect, specifically on students' thinking and learning. In this case, the structure afforded the opportunity for noticing. This concept of structured lesson study analysis meetings that include prompts to elicit noticing extends prior research on the development of noticing among prospective teachers. Specifically, this study and extends the work of Roth McDuffie et al. (2014) by providing a live teaching

context, as opposed to video, upon which the prospective teachers had opportunities to notice.

Although the lesson study model presented was modified from other versions of Lesson Study for the prospective teacher context, an attempt was made to uphold as many ideals of Lesson Study as possible. Despite these attempts, the backgrounds of the knowledgeable others, both the facilitator and classroom teacher in this study, differ from the typical experiences of knowledgeable others in different contexts (Watanabe 2011). Commonly, knowledgeable others have gained their expertise and experience from participating in Lesson Study; not from attending professional development on lesson study, as was the case with the knowledgeable others in the present study. We recognize that this difference may be necessary in the USA, where lesson study is not practiced on a wide scale; however, we make note of this distinction because of the crucial role the facilitator played in the process. This raises questions about the experiences of facilitators and the relationship between their backgrounds, knowledge, and role in the process.

Implications for teacher education programs

As teacher education programs work to promote the development of noticing, the role of the personnel instituting these changes, including course instructors and facilitators, should be considered to determine how these people may influence prospective teacher learning. In the present study, the facilitator and classroom teacher both afforded and constrained the inclusion of noticing through spoken words, thus influencing prospective teachers' opportunities to verbalize their noticing. This highlights the extremely important role of instructors in teacher education courses. Further research should explore the influence of knowledgeable others on Lesson Study in greater depth. More specifically, to build on this work and that of Corcoran (2011) who focused on positioning of knowledgeable others in Lesson Study, questions about how the perspectives or position of the knowledgeable other influence Lesson Study with prospective teachers should also be explored.

Conclusion

In an era with emphasis on preparing future elementary teachers to support students' mathematical learning effectively (Drake et al. 2014; Norton and McCloskey 2008; Roth McDuffie et al. 2014), and a focus on restructuring teacher education programs to include components supporting the development of noticing (van Es 2011; van Es and Sherin 2008), the lesson study context described shows some promise for providing an authentic setting for the verbalization of noticing. As noted, components of the conversations within the lesson study analysis meetings both afforded and constrained noticing; however, prospective teachers were able to attend, interpret, and make decisions about responding on the basis of students' mathematical thinking within this context (Jacobs et al. 2010). Therefore, we highlight the importance of considering participants, namely knowledgeable others, and their roles within a lesson study context, and argue for the plausible supports for learning to notice that this structure may provide.

Acknowledgments Support for this project was funded by the National Science Foundation Project #0732143. The ideas in this manuscript are solely generated by the authors and do not necessarily reflect those of the National Science Foundation. We would like to thank the PI and Co-PIs on the grant, Enrique Galindo, Valarie Akerson, Meredith Park Rogers, and Anderson Norton III.

Appendix

Observer_____**Date**_____

Teacher_____**Lesson** _____

Lesson Observation Form

***Review the objectives and plans for the lesson. Observe students at a table where at least one of your FAI students is sitting. Record observations, not inferences, in your field notes.**

Field Notes

Include anything students say or do which demonstrates their thinking about the topic and concepts. For example, you might include comments and/or questions in group and whole class discussions, engagement with materials, or written work, including drawings or representations. This section will have your raw notes to use for the two discussion/reflection items at the end of this form.

Discussion Items: Summary Reflection on Students' Thinking and Reasoning

*Based on your field notes, describe how the students at your table demonstrated their thinking and reasoning of the concepts in the lesson. Please provide specific evidence of your students' thinking and reasoning and refer to samples of students' work that constitute that evidence. If you make reference to your field notes when writing your response, please label (with a star, highlight, or underline) the part of your field notes that you are referencing and indicate that in your response as well (by communicating in your response for the reader to see the starred, highlighted, or underlined section of your field notes). If there are multiple references to your field notes in your response, please use different labels for each to help with clarification.

Discussion Items: Summary Reflection on How to Improve the Lesson

*Provide at least two suggestions for revising the lesson to improve student learning based on what you described above. If your suggestion(s) are based on anything you recorded in your field notes, please label (with a star, highlight, or underline) the part of your field notes from which your suggestion(s) emerged and make note of that in your suggestion(s) as well (by communicating in your suggestion/response for the reader to see the starred, highlighted, or underlined section of your field notes). If there are multiple references to your field notes in your response, please use different labels for each to help with clarification.

References

Amador, J., & Weiland, I. (2015). What preservice teachers and knowledgeable others professionally notice during lesson study. *The Teacher Educator*, *50*, 1–18.

Chichibu, T., & Kihara, T. (2013). How Japanese schools build a professional learning community by lesson study. *International Journal for Lesson and Learning Studies, 2*(1), 12–25.

Colestock, A., & Sherin, M. (2009). Teachers' sense-making strategies while watching video of mathematics instruction. *Journal of Technology and Teacher Education, 17*, 17–29.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research* (3rd ed.). Los Angeles: Sage.

Corcoran, D. (2011). Learning from lesson study: Power distribution in a community of practice. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 251–268). New York: Springer.

Creswell, J. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Los Angeles: Sage.

Drake, C., Land, T., & Tyminski, A. M. (2014). Using educative curriculum materials to support the development of pre-service teachers' knowledge. *Educational Researcher, 43*(3), 154–162.

Fernandez, C. (2002). Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education, 53*, 393–405.

Fernandez, M. (2010). Investigating how and what preservice teachers learn through microteaching lesson study. *Teaching and Teacher Education, 26*, 351–362.

Fernandez, M. L., & Zilliox, J. (2011). Investigating approaches to lesson study in preservice mathematics teacher education. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 85–102). New York: Springer.

Franke, M., Carpenter, T., Levi, L., & Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Journal, 38*, 653–689.

Fujii, T. (2014). Implementing Japanese Lesson Study in foreign countries: Misconceptions revealed. *Mathematics Teacher Education and Development, 16*(1), 65–83.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago: Aldine.

Hart, L., & Carriere, J. (2011). Developing the habits of mind for a successful lesson study community. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 27–38). New York: Springer.

Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education, 41*, 169–202.

Jacobs, J. K., & Morita, E. (2002). Japanese and American teachers' evaluations of videotaped mathematics lessons. *Journal for Research in Mathematics Education, 33*, 154–175.

Lewis, C., Perry, R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education, 12*, 285–304.

Marble, S. (2007). Inquiry into teaching: Lesson study in elementary science methods. *Journal of Science Teacher Education, 18*, 935–953.

Mason, J. (2002). *Researching your own practice: The discipline of noticing*. New York: Springer.

Mason, J. (2011). Noticing: Roots and branches. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 35–50). New York: Routledge.

Miller, K. (2011). Situation awareness in teaching: What educators can learn from video-based research in other fields? In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 51–65). New York: Routledge.

Murata, A. (2011). Introduction: Conceptual overview of lesson study. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 1–12). New York: Springer.

Murata, A., Bofferding, L., Pothen, B., Taylor, M., & Wischnia, S. (2012). Making connections among student learning, content, and teaching: Teacher talk paths in elementary mathematics lesson study. *Journal for Research in Mathematics Education, 43*, 616–650.

Murata, A., & Pothen, B. (2011). Lesson study in preservice elementary mathematics methods courses: Connecting emerging practice and understanding. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 103–116). New York: Springer.

Norton, A., & McCloskey, A. (2008). Teaching experiments and professional development. *Journal of Mathematics Teacher Education, 11*, 285–305.

Perry, R., & Lewis, C. (2009). What is successful adaptation of lesson study in the US? *Journal of Educational Change, 10*, 365–391.

Philipp, R., Ambrose, R., Lamb, L., Sowder, J., Schappelle, B., Sowder, L., et al. (2007). Effects of early field experience on the mathematical content knowledge and beliefs of preservice elementary school teachers: An experimental study. *Journal for Research in Mathematics Education, 38*, 438–476.

Potari, D. (2011). Response to part II: Emerging issues from lesson study approaches in preservice mathematics teacher education. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 127–132). New York: Springer.

Roller, S. (2015). What they notice in video: A study of perspective secondary mathematics teachers learning to teach. *Journal of Mathematics Teacher Education*. doi:10.1007/s10857-015-9307-x.

Roth McDuffie, A., Foote, M. Q., Bolson, C., Turner, E. E., Aguirre, J. M., Bartell, T. G., et al. (2014). Using video analysis to support preservice K-8 teachers' noticing of students' multiple mathematical knowledge bases. *Journal of Mathematics Teacher Education, 17*, 245–270.

Sherin, M. G., Jacobs, V., & Philipp, R. (2011). Situating the study of teacher noticing. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 3–14). New York: Routledge.

Sherin, M. G., & van Es, E. A. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education, 13*, 475–491.

Shimizu, Y. (2002). *Sharing a new approach to teaching mathematics with the teachers from outside the school: The role of lesson study at 'Fuzoku' schools*. Paper presented at the US-Japan Cross Cultural Seminar on the Professionalization of Teachers Through Lesson Study, Park City, Utah.

Stake, R. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.

Stake, R. (2005). *Qualitative research: Studying how things work*. New York: Guilford Press.

Star, J., Lynch, K., & Perova, N. (2011). Using video to improve preservice mathematics teachers' abilities to attend to classroom features. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 117–133). New York: Routledge.

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice teachers' ability to notice. *Journal of Mathematics Teacher Education, 11*, 107–125.

Steffe, L., & Thompson, P. (2000). Teaching experiment methodology: Underlying principles and essential elements. In A. E. Kelley & R. A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 267–306). Mahwah, NJ: Lawrence Erlbaum Associates.

Stigler, J., & Hiebert, J. (1999). *The teaching gap*. New York: Free Press.

Takahashi, A. (2011). Response to part 1: Jumping into lesson study—Inservice mathematics teacher education. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 79–82). New York: Springer.

van Es, E. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. Jacobs, & R. Philipp (Eds.), *Mathematics teacher noticing* (pp. 134–151). New York: Routledge.

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*, 571–596.

van Es, E., & Sherin, M. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education, 24*, 244–276.

Watanabe, T. (2011). Response to part III: Challenges and promises of uncharted water—Lesson study and institutions of higher education. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 175–178). New York: Springer.

Weiland, I., Hudson, R., & Amador, J. (2014). Preservice formative assessment interviews: The development of competent questioning. *International Journal of Science and Mathematics Education*, *12*, 329–352.

Weiland, I., Park Rogers, M., Amador, J., Akerson, V., & Pongsanon, K. (under review). Using an iterative based-based lesson study approach in preservice elementary science teacher education. *International Journal of Science Education*.

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Los Angeles: Sage.

Yoshida, M., & Jackson, D. (2011). Response to part V: Ideas for developing mathematical pedagogical content knowledge through lesson study. In L. Hart, A. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education: Learning together* (pp. 279–288). New York: Springer.