Attending to and fostering argumentation in whole class discussion

Markus Hähkiöniemi[1], Pasi Nieminen[1], Sami Lehesvuori[1], John Francisco[2], Jenna Hiltunen[3], Kaisa Jokiranta[1] and Jouni Viiri[1]
[1]University of Jyvaskyla, Department of Teacher Education, Finland; [2]University of Massachusetts, Amherst, MA, USA; [3]University of Jyvaskyla, Finnish Institute for Educational Research, Finland

Prior studies highlighted the importance of whole class discussion after student activities and have focused, for example, on teacher moves in supporting discussion. We characterize two processes in teacher-students interaction in argumentation discussions: attending to and fostering. These processes describe how student argumentation feeds teacher talk that in turn feeds student argumentation. We analysed video recordings of one whole class 7th grade lesson when students made geometric constructions and engaged in argumentation discussion. We elaborated on four themes in how the teacher talk attended to and fostered student argumentation. We argue that the concepts of attending to and fostering help to understand how teachers can orchestrate argumentation discussions.

Introduction

This study focuses on the relationship between teacher talk and student argumentation in mathematics learning in lower secondary school. Often argumentation in mathematics education is considered from the cognitive point of view of what students consider as a proof or how they construct proofs or justifications (e.g., Harel & Sowder, 2007). Another line of research focuses on collective argumentation and consider argumentation as a social phenomenon in which students and the teacher together present rationale for their actions (Krummheuer, 1995). Often Toulmin's model is used to recognize argumentation components such as claim, data and warrant (e.g., Conner, Singletary, Smith, Wagner, & Francisco, 2014; Berland & McNeill, 2010). Some studies have also identified teacher moves that support students' work related to argumentation components (Conner et al., 2014). In this study, we continue to focus on collective argumentation and study argumentation as discussion in which students and the teacher pose claims, defend claims and criticize others' arguments.

Teacher talk is one of the key elements in facilitating argumentation discussion as teachers orchestrate classroom work by harnessing and interweaving students' contributions and making shifts between what is foregrounded and what is

backgrounded in pursuit of overall pedagogical goals (Littleton & Kerawalla, 2012). Orchestrating productive classroom discussion after student activities has been recognized as an important but challenging phase in mathematics teaching (Stein, Engle, Smith, & Hughes, 2008). We think that this phase of a lesson may be even more important when the aim of the lesson is to engage students in argumentation discussion.

Previous studies have identified different types of teacher talk on the basis of how different points of view are discussed and who participates in the discussion (e.g., Lehesvuori, Viiri, Rasku-Puttonen, Moate, & Helaakoski, 2013). Some studies have characterized specific teacher moves that stimulate student thinking. For example, Temple and Doerr (2012) created categories for mathematics teachers' initiation (comparing, defining, describing, evaluating, hypothesizing, recounting, representing) and feedback (clarification requests, elicitation, evaluation request, expansion, explicit correction, justification request, metalinguistic feedback, recast, reinforcement, repetition) moves. Similarly, Chin (2007) identified questioning approaches (Socratic questioning, verbal jigsaw, semantic tapestry, and framing) with subcategories that stimulated productive thinking. Both Temple and Doerr (2012) and Chin (2007) found that the teacher moves depended on the purpose of the episode. However, relatively few studies (Conner et al., 2014) have explored the relationship between teacher talk and student argumentation in mathematics. As a result, research providing a more thorough understanding of the relationship between teacher talk and student argumentation is still needed.

To study the relationship between teacher talk and student argumentation, we draw on the concepts of attending to and fostering by building on previous research (Lobato, Clarke, & Ellis, 2005; Sherin, Jacobs, & Philipp, 2011). Teacher talk which *attends to* student argumentation is sensitive to the students' arguments, for example, by drawing out the students' ideas in a dialogue or by reviewing the arguments in a lecture. Attending to refers to a process in which student argumentation influences teacher talk. *Fostering* means that the teacher intends to move student argumentation forward, for example, through questioning or using examples. In fostering, the teacher's talk influences the students' argumentation. The same teacher utterance can indicate both the processes of attending to and fostering. For example, when a teacher rephrases students' argument using formal mathematical notation, this indicates that the teacher talk attends to the students' argumentation and fosters argumentation by introducing new notations.

The aim of this study is to elaborate on the concepts of attending to and fostering and to examine how these concepts may enrich the analysis of teacher orchestrated whole class argumentation discussion. One mathematics lesson was selected for this study. The following research question guided the data analysis: How does the teacher's talk attend to and foster students' argumentation?

Methods

The reported study is part of a two-year research project investigating how the participating classes develop in argumentation discussion when using argumentation tasks regularly in mathematics and in physics. For this study, we selected one 7th grade mathematics lesson from the project database for a more detailed analysis. The criteria for selecting the lessons was that it included relatively high level whole class discussion in which students talked mathematics to each other. The participants were informed about the study and gave research consents. The results are reported using pseudonyms.

Data collection

The lesson was the fifth lesson of the teacher and the students in the project. The students (n = 25) were seventh grade students. The teacher was an experienced mathematics and science teacher. The topic of the 45 minutes long lesson was geometric constructions. Students were working in six groups (A, B, C, D, E and F) to construct a quadrangle that has four equal sides (a rhombus) and prepared to explain why their construction was valid. During the group work, the teacher circulated in groups. The students produced posters of their constructions. Then, the students observed other groups' posters and prepared to comment on them in the forthcoming whole class discussion. Finally, several posters were discussed during a whole class discussion.

The lesson was video recorded with a handheld video camera which followed the teacher from the back of the classroom. The camera was connected to a wireless microphone on the teacher. In addition, each student group had a small wide angle GoPro-camera attached to their desk. Students' verbal comments were recorded on the video's audio. Students' posters were collected.

Data analysis

The analysis started as two researchers observed the lesson live. Afterwards, the lesson video and particularly the whole class discussion were watched several times. In the data driven analysis, data was reduced into segments around each teacher utterances, the segments were then divided into groups and the groups were elaborated (Miles & Huberman, 1994). In detail, for every teacher utterance, it was considered how the utterance related to the ongoing student argumentation that preceded the teacher utterance. In addition, each input the teacher utterances gave for student argumentation was analysed. By comparing these instances with each other similarities and differences were noted and the episodes were divided into groups. The episodes in each group were compared to each other and common features were characterized. Through this, we composed four themes in how teacher talk attended to and fostered student argumentation.

Results

In the following, we elaborate on the four themes adressing how the teacher's talk attended to and fostered student argumentation. The given exerptcs are from the whole class discussion.

Supporting students to direct their talk to other students

In the beginning of the whole class discussion, when discussing the solution of Group A (Fig. 1), the teacher tried to get the students to talk to each other instead of talking just to the teacher.

1	Alex	At least it looks like a pretty good square.
2	Teacher	It looks like a good square. What is it Joe?
3	Joe	Why there is a circle? (…)
4	Teacher	Why there is a circle? (Directs the question to Rebecca.)
5	Rebecca	Because it had to be done by compass. Then we started do the square with the help of the circle. It had to be done geometrically, and so, we did the circle and then it was easier to do it.
6	Teacher	Did that answer you Joe?
7	Joe	Yeah.
8	Teacher	Anything else?
9	Robert	How did you do those that go up there and to the side. Those lines in the middle. How did you get them exactly in 90 degrees angle?
10	Rebecca	Well, we turned the ruler?
11	Robert	So you cannot prove in any way that.
12	Rebecca	We estimated it by eye.

The teacher talk attended to Alex's statement by repeating it (turn 2). This indicated that the statement had been heard. The teacher did not evaluate the statement, which fostered the discussion to continue. In turn 4, the teacher directed Joe's question to Rebecca. Here teacher talk attended to the fact that students were talking to the teacher instead of talking to each other. The same teacher utterance also fostered the students talking to each other. In turn 6, the teacher reinforced that the purpose is for students talk to each other by asking Joe to comment on Rebecca's response. After this, the discussion continued, and the teacher highlighted that estimating by eye is not accepted method in geometric construction. Thus, the discussion in this episode included important elements of argumentation as ideas were critically analysed and weaknesses were found.

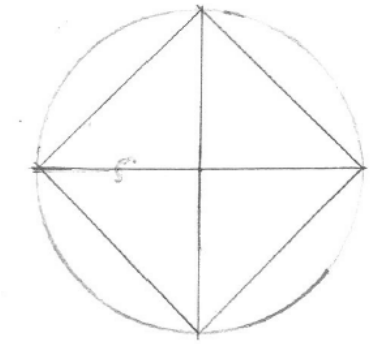

Figure 1: The solution of Group A

After the above episode, the teacher fostered student-to-student discussion by talking about discussion rules:

> Wait a minute. I have one thing that I would like to say. The first thing is that if you come up with an idea, you don't have to ask my permission. Clearly, Alex had something in his mind. So discuss, and others will listen, what one has to say. Alex.

In the excerpt above, teacher talk again attended to the need to get the students to talk to each other and fostered this by explicitly pointing this out. Later, when discussing the solution of Group B (Fig. 2), the teacher again supported student–student discussion:

14	Teacher	Carl, tell us.
15	Carl	Why there are two circles there?
16	Oliver	I can come to explain.
17	Teacher	You don't have to come to explain. Just answer Carl's question. Why-
18	Oliver	Carl, well, first we draw the outer circle and then the inner circle is just because of the angle bisectors because we did not want to draw all the small arcs separately, but we draw the full circle. It was easier. (Turning toward Carl and talking to him. Carl is nodding.)

Carl, who was not part of Group B, asked a question about the work of Group B. Oliver from Group B offered to answer the question. In turn 17, the teacher forbade Oliver to come in the front of the class to explain but instead wanted Oliver to answer to Carl from his own seat. The teacher attended to the potential of student explaining an idea to another student and fostered this by requesting Oliver to response directly to Carl. In this case, Oliver turned toward Carl, mentioned his name and explained to him. Thus, the teacher move was successful in promoting student-student discussion.

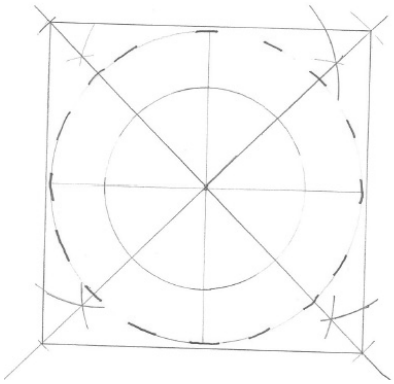

Figure 2: The solution of Group B

Seizing the potentially fruitful student utterances and using these to feed the argumentation

When Oliver continued to answer other students' questions there was a point in which Robert challenged the need to draw a certain circle:

19	Oliver	Yes you need to have those circles
20	Robert	I challenge that.
21	Teacher	Why do you challenge that?

The teacher talk attended to Robert's expression that he did not agree with Oliver and also fostered Robert to explain reasons for why he did not agree. In other words, the teacher talk attended to a disagreement and fostered counterargument. In addition, the teacher highlighted that when challenging ideas, reasons have to be explained. After the teacher's question, Robert explained how he would have modified Oliver's drawing. When Oliver responded, it became clear that his group had thought differently than Robert.

After the above discussion, Rebecca said that she did not understand anything:

22	Teacher	Do the others have something to comment on?
23	Rebecca	I don't understand anything of that.
24	Teacher	You don't understand anything. Good. Great. What do you not understand?
25	Rebecca	I don't understand anything.
26	Teacher	You don't understand anything.
27	Rebecca	I don't get the logic. (…)
28	Teacher	Do you know what? That is a brilliant answer. That is a brilliant answer. Do you know Oliver, you have a small problem.
29	Oliver	I know.
30	Teacher	Rebecca did not understand anything, and you should explain so that Rebecca and I too will

		understand, because I too have not understood anything yet.

In the turns 24, 26, 28 and 30, teacher talk attended to Rebecca's difficulties in understanding and to the need to explain in more detail. The teacher seized on the Rebecca's genuine expression of not understanding and used this as a springboard to foster Oliver to explain their line of reasoning in more detail. Furthermore, the teacher again attended to and fostered discussion rules by expressing that it is good to say when something is not understood and that others can be asked to explain in more detail.

Guiding the discussion to focus on the mathematical content of the argument

After the above episode, Oliver continued to explain their construction method, and there were more questions from the students.

31	Mike	Why did you bisect those angles?
32	Oliver	To get, u-hum. We bisected them to get like exactly 90 degrees here. So if this had been here and this here, then it would not have produced a square.
33	Robert	Is the angle in those radius 90 degrees?
34	Oliver	I'm not sure.
35	Teacher	Argh. Argh.
36	Oliver	Let's agree that it is. (Teacher laughs friendly.)
37	Robert	Oliver, Oliver, if it is 90 degrees, then how did you do it?
38	Oliver	Estimating by eye (with laughing voice).
39	Teacher	Argh.
40	Oliver	I know. We should have done it differently.

In turns 35 and 39, the teacher made sounds that signalled that something went wrong. The teacher did this in friendly manner. He attended to the insufficient justification and fostered students paying attention to this relevant issue of geometric constructions.

The teacher talk attended to and fostered the mathematical content of the argument in other points of discussion too. For example, he asked why-questions to get the students to discuss reasons, asked about specific steps to help students to describe what they did in their construction and asked to think about the construction instead of how the result looks like.

Not attending to a potentially relevant issue

Besides attending to several relevant and evidently productive issues in student argumentation, the teacher did not attend to all potentially relevant issues. One such episode happened when discussing the already mentioned solution of Group A.

41	Mike	After you draw the first line to the circle, if you had done a perpendicular line-
42	Robert	No, perpendicular bi-
43	Mike	perpendicular bisector to that line in the middle, then you would have got 90 degrees angle there, and you would have been able to connect the vertices as a square.
44	Olive	What is a perpendicular line?
45	Rebecca	What is a perpendicular bisector?

In this case, the teacher did not say anything about Mike's idea of correcting the construction of the other group. With Mike's correction, the construction would have been exact and there would have been a potential to construct other rhombuses than squares with the same technique. The attention of the teacher was potentially directed to the fact that some students did not know what a perpendicular line is even though that had been studied. The teacher also mentioned that the students should know this by now.

Discussion

In this study, we have analysed one lesson that included whole class argumentation discussion in which students talked mathematics to each other. The teacher talk played an important role in the discussion. The teacher used talk to attend to relevant points in the discussion and foster students to direct their talk to other students. In addition, the teacher spotted potentially fruitful student utterances and used these to feed the argumentation. He also guided the discussion to focus on the mathematical content of the argument. These three themes illustrate three dimensions of teacher orchestration: student–student dialog, argumentation components and content of argumentation. Previous research has studied classroom dialogue (e.g., Lehesvuori et al., 2013), components of argumentation based on the elements in Toulmin's model (1958/2003) and content of argument by examining if the argument is based on deductive or other forms of reasoning (e.g., Harel & Sowder, 2007). This study points to the need to include all these dimensions in the analysis of argumentation discussions. As shown in the results, the teacher in this study orchestrated the discussion in all these aspects. If focusing only on one dimension, we may miss important contribution of teacher talk.

In orchestrating the discussion, the teacher talk attended to the ongoing student argumentation and fostered it. Attending to meant that the teacher picked up ideas in students' argumentation and used these in his talk. When fostering, the teacher gave input to the students' argumentation. This relationship between teacher talk and student argumentation resembles to the concepts of uploading and downloading by Tabach, Hershkowitz, Rasmussen and Dreyfus (2014). According to Tabach et al., the ideas that students have developed during group work can be

uploaded to the whole class discussion. Students can also download ideas from whole class discussion to their group work. Similarly, when attending to, the teacher downloads something from students into his talk. When fostering, then teacher is uploading something into students work. The difference between attending to/fostering and downloading/uploading is that the same teacher talk can be attending to and fostering. Thus, attending to and fostering are like two sides of the same coin. This also differentiates the concepts from eliciting and initiating, as proposed by Lobato et al. (2005). Another difference is that when a teacher is attending to, he or she does not necessarily try draw out students' ideas. There are also some similarities to the framework by Conner et al. (2014) who consider teacher moves that are related to different components of Toulmin's model. A difference is that attending to and fostering do not focus only on argumentation components but also to student–student dialog.

We found the concepts of attending to and fostering helpful in examining how the teacher orchestrated the whole class discussion. In particular, through attending to and fostering, we recognized the bi-directional flow of ideas from students to the teacher and from the teacher to the students. However, this study focused only on one lesson. Thus, the concepts of attending to and fostering are still preliminary concepts which need to be further elaborated in other lessons and in different contexts. In the ongoing project, we continue to study teachers' practices and investigate subtle differences in attending to and fostering.

Acknowledgment
This work has been funded by the Academy of Finland (project number 286576).

References

Berland, L. K., & McNeill, K. L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education*, *94*(5), 765–793.

Chin, C. (2006). Classroom interaction in science: Teacher questioning and feedback to students' responses. *International Journal of Science Education, 28*(11), 1315–1346.

Conner, AM., Singletary, L.M., Smith, R.C., Wagner, P.A., & Francisco, R.T. (2014). Teacher support for collective argumentation: A framework for examining how teachers support students' engagement in mathematical activities. *Educational Studies in Mathematics, 86*(3), 401–429.

Harel, G., & Sowder, L. (2007). Toward comprehensive perspectives on the learning and teaching of proof. In F. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 805–842). Charlotte: Information Age Publishing.

Krummheuer, G. (1995). The ethnography of argumentation. In P. Cobb & H. Bauersfeld (eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 229–269). Hillsdale, NJ: Lawrence Erlbaum.

Lehesvuori, S., Viiri, J., Rasku-Puttonen, H., Moate, J., & Helaakoski, J. (2013). Visualizing communication structures in science classrooms: Tracing cumulativity in teacher-led whole class discussions. *Journal of Research in Science Teaching, 50*(8), 912–939.

Littleton, K., & Kerawalla, L. (2012). Trajectories of inquiry learning. In K. Littleton, E. Scanlon & M. Sharples (Eds.), *Orchestrating inquiry learning* (pp. 31–47). London: Routledge.

Lobato, J., Clarke, D., & Ellis, A.B. (2005). Initiating and eliciting in teaching: A reformulation of telling. *Journal for Research in Mathematics Education, 36*(2), 101–136.

Miles, M., & Huberman, A. (1994). *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Sherin, M., Jacobs, V., & Philipp, R. (eds.) (2011). *Mathematics teacher noticing. Seeing through teachers' eyes*. NY: Routledge.

Stein, M., Engle, R., Smith, M., & Hughes, E. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning, 10*, 313–340.

Tabach, M., Hershkowitz, R., Rasmussen, C., & Dreyfus, T. (2014). Knowledge shifts and knowledge agents in the classroom. *The Journal of Mathematical Behavior*, *33*, 192–208.

Temple, C., & Doerr, H. M. (2012). Developing fluency in the mathematical register through conversation in a tenth-grade classroom. *Educational Studies in Mathematics, 81*(3), 1–20.

Toulmin, S. E. (2003). *The uses of argument* (updated ed.). New York: Cambridge University Press. Originally published in 1958.