Author(s): Hähkiöniemi, Markus

Title: Student teachers' questioning behaviour which elicit conceptual explanation from students

Year: 2016

Version:

Please cite the original version:

Hähkiöniemi, M. (2016). Student teachers' questioning behaviour which elicit conceptual explanation from students. In C. Csíkos, A. Rausch, & J. Szitányi (Eds.), PME40 : Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education. Volume 2 (pp. 337-344). International Group for the Psychology of Mathematics Education. Proceedings of the PME Conference.

2016. In Csíkos, C., Rausch, A., & Szitányi, J. (Eds.). *Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education*, Vol. 2, pp. 337 – 344. Szeged, Hungary: PME.

STUDENT TEACHERS' QUESTIONING BEHAVIOUR WHICH ELICIT CONCEPTUAL EXPLANATION FROM STUDENTS

Markus Hähkiöniemi

University of Jyvaskyla

Getting students to explain their thinking is one of the big challenges in teachers' work. Previous studies have analysed teacher questioning by focusing on amounts of different types of questions. In this study, I use questioning diagrams to see how questioning develops during the lessons. The data includes video recordings of student teachers' mathematics lessons in secondary and upper secondary school. The data is analysed by constructing questioning diagram for each student teacher and locating conceptual explanations given by students. The lessons which included largest amount of conceptual explanations are further studied. In these lessons the student teachers had lengthy discussions with the students and asked them many kinds of questions.

INTRODUCTION

An essential part of teacher-student interaction is to get students explain their thinking. Explaining is necessary condition for dialogic interaction because ideas need to be shared. In addition, even explaining to one self supports learning because of so called self-explanation effect (Wong, Lawson, & Keeves, 2002). However, there are different kinds of explanation. Kazemi and Stipek (2001) described two classrooms: one where students explained procedures (steps) and one where students explained reasons (why). The teachers in these classes pressed differently for conceptual thinking although some features of teaching were the same.

The two kinds of explanations described by Kazemi and Stipek (2001) correspond to procedural and conceptual knowledge. Procedural knowledge includes procedures which are used to solve problems and conceptual knowledge includes connections between pieces of knowledge (Hiebert & Lefevre, 1986). When explaining reasons, one makes connections. Thus, in this paper, these two kinds of explanations are called procedural and conceptual explanations.

The conceptual and procedural explanations also compares to Toulmin's model (1958). In Toulmin's model a claim (e.g., an answer to a task) is supported by data. Warrant indicates how the claim follows from the data. Thus, procedural explanation describes data for the claim and conceptual explanation gives the warrant.

Teachers can elicit student explanation through questioning. Sahin and Kulm (2008) characterize three kinds of questions: factual questions request a known fact, guiding questions give hints or scaffold solution, and probing questions ask for elaboration, explanation or justification. The first step in getting students to explain is to ask probing questions. However, even though a teacher is asking probing questions it does not mean that students will explain. Franke et al. (2009) found that even follow-up questions did not guarantee explanation. According to their results, the best way to help students give a correct and complete explanation, was asking a probing sequence of specific questions.

In previous studies questioning has been studied by calculating frequencies of questions (e.g., Hähkiöniemi, 2013). This kind of analysis does not consider how questioning develops and progress over time. Lehesvuori, Viiri, Rasku-Puttonen, Moate and Helaakoski (2013) have included this kind of temporal consideration in their analysis by using interaction diagrams which depict the types of teacher talk as a function of time.

This study contributes to studying teacher questioning and student explanation by using questioning diagrams which give more holistic picture of teacher questioning. The aim of this study is to understand what kind of teacher questioning gets students to give conceptual explanations to probing questions. The following research question guided the data analysis: How do student teachers, whose students give conceptual explanations, ask questions?

METHODS

Data collection

The participants of this study consist of 29 Finnish prospective secondary and upper secondary mathematics teachers. The student teachers were in the final phase of the teacher training program. They all had taught several school lessons during the program. The student teachers participated in an inquiry-based mathematics teaching unit taught by the author. The unit included nine 90 minutes group work sessions about the ideas of inquiry-based mathematics teaching. For example, the student teachers practiced how to guide students in hypothetical teaching situations (see, Hähkiöniemi & Leppäaho, 2012). After the unit, each student teacher implemented one inquiry-based mathematics lesson in grades 7–12. All the lessons were structured in the launch, explore, and discuss and summarize phases. During the explore phase students usually worked in pairs or in three person groups. Altogether, there were 16 lessons in secondary school (grades 7–9) and 13 lessons in upper secondary school (grades 10–12). Lesson length was 45 minutes in the secondary school and either 45 or 90 minutes in the upper secondary school. Students used GeoGebra software to solve problems in 17 lessons.

The lessons were videotaped and audio recorded with a wireless microphone attached to the teacher. The video camera and the microphone were synchronized. The hand-held video camera followed the teacher as he or she moved around the classroom. When the teacher discussed with a student pair, the camera was positioned so that students' notebooks or computer screens could be seen. Although the microphone was attached to the teacher, it captured also students' talk when the teacher discussed with a group of students. Students' written notes were collected after each lesson.

Data analysis

Data was analyzed using Atlas.ti video analysis software. All the teachers' questions were coded to probing, guiding, factual, and other questions. The definitions for these codes were constructed on the basis of Sahin and Kulm's (2008) characterizations. The shortened versions of the definitions are as follows:

- Probing questions (code 1): Questions which request students to explain or examine their thinking, solution method or a mathematical idea.
- Guiding questions (code 2): Questions which potentially give students hints or guides solving a problem. Potentially means that students do not have to understand the hint but the questions offers opportunity for this. Probing questions are excluded from this category.
- Factual questions (code 3): Questions that ask for a known fact such as an answer to a task, a definition, or a theorem. Guiding questions are excluded from this category. The difference to a guiding question is that students are not solving a problem and the question does not guide or give hint to solving the problem.
- Other questions (code 4): All other questions such as questions concerning classroom control.

A teacher utterance was considered as a question if it invited the students to give an oral response. For example, utterances such as "explain" were considered as questions even though grammatically they are not questions. On the other hand, grammatical questions were not coded as questions if the teacher did not give the students a possibility to answer the question. Inter-rater reliability for coding probing, guiding, factual, and other questions for a sample of 150 questions was 89 % (Cohen's kappa = .845).

In addition, lessons were coded to launch, explore, and discuss and summarize phases. The episodes when the teacher discussed with a certain student group during the explore phase were marked. After this, questioning diagrams of each student teacher were produced using SPSS and spreadsheet software (see, e.g., Fig. 1). In the diagrams, the horizontal axis shows the time in minutes and vertical axis shows the question type. The beginning and the end of the lesson as well as the lesson phases are indicated by vertical lines. In the exploration phase, the questions asked from a student group (or an individual student) are connected with a line. Questions are marked with red circles or blue triangles so that the symbol changes when the group changes. Questions asked during the launch and discuss and summarize phases are marked with green squares on connected with a line.

After producing the questioning diagrams, students' responses to teachers' probing questions were coded as follows:

- Conceptual explanation: Expresses *why* a result or an intermediate step is achieved using some method, why a property holds or do not hold, or how something represent or means something or how concepts are related
- Procedural explanation: Expresses how a result or step is achieved or how something is done or describes representations
- No explanation

The conceptual explanations were marked with C in the questioning diagrams. Also when a conceptual explanation was identified, it was checked if the teacher had already discussed with this student group and if so these discussions were connected by dashed line.

I looked for lessons in which several student teachers probing questions were answered by conceptual explanations in the explore phase of the lesson. I selected those student teachers whose lessons contained five or more conceptual explanations. I considered these lessons to include high number of conceptual responses because in the other lessons the number of conceptual responses was between 0 and 3. I searched for commonalities and differences in the selected student teachers' questioning diagrams. After this I turned to microanalysis of the video episodes in which conceptual explanations were given.

RESULTS

In four lessons students gave five or more conceptual responses to student teachers probing questions. In these lessons several different students gave the conceptual explanations. The questioning diagrams of these student teachers are given in Figure 1.

Common feature in student teachers 8, 9 and 11 questioning diagrams is that they asked many different kinds of questions from the same students. Thus, based on the diagrams, they engaged in long discussions with the students.

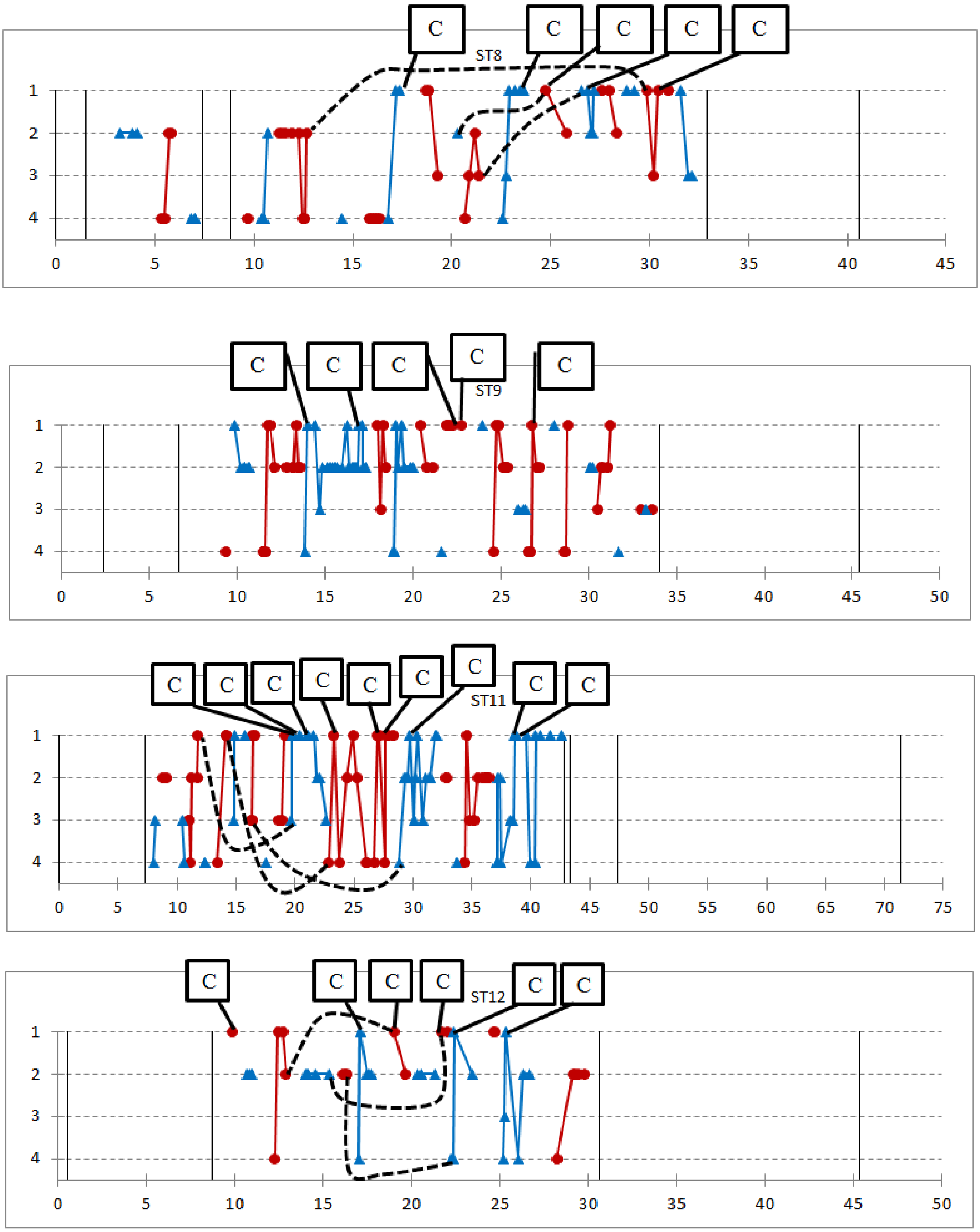

Figure 1: Questioning diagrams of the student teachers whose lessons contained five or more conceptual explanations (1 = probing question, 2 = guiding question, 3 = factual question, 4 = other question, C = conceptual explanation)

The questioning diagram of student teacher 12 seems at first a bit different. However, when we look at how he returned to ask questions from the groups after visiting other groups (dashed lines in Fig. 1), it seems that also he is asking many different questions from the same students, but not just in a row. For example, he first visited a pair of students who were solving how much juice can be made of 1.5 litres of concentrate when 30 % of the juice has to be concentrate:

ST 12: How are you succeeding? [Other question, time 12:15]

Student 1: [Mumbles]

ST 12: Okay, let's see.

Student 2: Is it correct?

ST 12: It isn't quite correct. Let's see. What have you done here? Tell me. Let's see where it goes wrong. [Probing question]

Student 2: Uhm. I don't know. We thought that 30 %, it has to be multiplied by 7. [Procedural explanation]

ST 12: Why it has to be multiplied by 7? [Probing question]

Student 2: I don't know.

Student 1: I would have understood, that I think that you multiply by 0.70. [Procedural explanation]

The students had solved the task as shown in the crossed part of figure 2. The student teacher asked why the students had multiplied by seven and thus started to probe reasons. Then the student teacher guides students to use *x* and lefts the student to continue. Later he comes back to this group:

ST 12: Explain a little what you have done here. [Probing question, time 18:58]

Student: We took first 10 % which is this 0.5. Then we multiplied it by 7 to get 70 %. Then we added the 30 % to 70 %. [Conceptual explanation]

The students were still not using *x* but now they gave a conceptual explanation. The explanation is conceptual because in addition to describing the steps, the student also indicates that 0.5 is multiplied by 7 to get 70 % in this case.

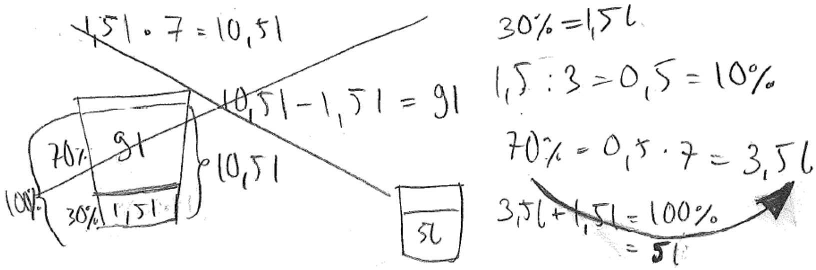

Figure 2: Students' solution of how much juice can be made of 1.5 litres of concentrate when 30 % of the juice has to be concentrate.

Also two other student teachers returned to a previously visited group when they got conceptual explanations (see Fig. 1.). Only student teacher 9 did not visit the groups which gave conceptual explanation before.

In many cases the probing question which yielded a conceptual response was not the first question or the first probing question. For example, student teacher 8 asked questions from a group who had drawn a line representing a situation in which entrance fee is 2 euros and time based fee is 5 €/h:

ST 8:	What is the meaning of your line? [Probing question, time 16:48]
Student:	It is the second task. [No explanation]
ST 8:	Okay. Yeah. On what grounds did you think that it would be like that? [Probing question]
Student:	Because here are euros and here is time and always when it plays an hour it is 5 €. And here it has played 2 h, then it is 10 €. [Conceptual explanation]

The students did respond properly to the first probing question. When the teacher reworded the question, the students gave a conceptual explanation. Also in the other lessons, which contained fewer conceptual responses, the conceptual explanations were often given when the teacher asked many different types of questions or when the teacher focused the probing question based on the student's response.

DISCUSSION

The results of this study show in what kind of conditions it is possible to get the students to give conceptual responses to probing questions. One of these conditions is that the student teachers engage in lengthy discussion with the students and asks several different types of questions. These kinds of discussion can be regarded as more authentic than short discussions following initiation-response-evaluation pattern (Mehan, 1979; cf. Lehesvuori & al., 2013).

Another feature which is connected to getting the students to give conceptual questions, is asking several probing questions in a row so that when students give non-conceptual response, student teacher modifies the question based on students' responses. Similarly Franke et al. (2009) noticed that probing sequence of specific questions was most efficient way to get the students to give a correct and complete explanation. Thus, the results of this study support Franke et al.'s (2009) findings.

Also returning to ask questions from the same students was used when students gave conceptual explanations. Keeping track of all the different paths taken by the students, supporting and even relating them to each other is one of the big challenges in orchestrating students' problems solving (Stein, Engle, Smith, & Hughes, 2008). When a teacher manages to keep track and return to continue the discussion, the students are perhaps in better position to express their idea as they had time to think.

The questioning diagrams were useful research tool as they made it possible to compare student teachers' questioning more holistically and notice commonalities and differences. In future research, the questioning diagrams could be used to study how teachers' questioning habits change over time.

References

Franke, M., Webb, N., Chan, A., Ing, M., Freund, D., & Battey, D. (2009). Teacher questioning to elicit students' mathematical thinking in elementary school classrooms. *Journal of Teacher Education, 60*(4), 380–392.

Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: An introductory analysis. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: the case of mathematics* (pp. 1-27). Hillsdale, NJ: Lawrence Erlbaum.

Hähkiöniemi, M. (2013). Probing student explanation. In A. Lindmeier, & A. Heinze (Eds.), *Proceedings of the 37th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 401–408). Kiel, Germany: PME.

Hähkiöniemi, M., & Leppäaho, H. (2012). Prospective mathematics teachers' ways of guiding high school students in GeoGebra-supported inquiry tasks. *The International Journal for Technology in Mathematics Education, 19*(2), 45–58.

Kazemi, E., & Stipek, D. (2001). Promoting conceptual thinking in four upper-elementary mathematics classrooms. *The Elementary School Journal, 102*(1), 59–80.

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.

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

Sahin, A., & Kulm, G. (2008). Sixth grade mathematics teachers' intentions and use of probing, guiding, and factual questions. *Journal of Mathematics Teacher Education, 11*(3), 221–241.

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.

Toulmin, S. (1958). *The Uses of Argument*. Cambridge: Cambridge University Press.

Wong, R., Lawson, M., & Keeves, J. (2002). The effects of self-explanation training on students' problem solving in high-school mathematics. *Learning and Instruction, 12*, 233–262.