Teacher moves for promoting student participation when teaching functional relationships to language learners

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Students' participation in rich discourse practices is important for their understanding of the meaning of mathematical concepts. It is the job of the teacher to enable and foster this participation. But how exactly do teachers' practices for promoting beneficial student participation in classrooms look like for a specific mathematical concept? This paper investigates two contrasting cases to explore the range of possible topic-related moves teachers use when teaching functional relationships to monolingual and multilingual academic language learners. The two cases illustrate topic-specific and topic-independent teacher moves by which teachers try to promote student participation in a discussion on comparing functional relationships with regard to their meaning in the given contexts.

Keywords: Teacher moves, student participation, functional relationships, comprehension elements.

Introduction

The quality of communication and discourse in classrooms is crucial for students' learning of mathematics (e.g. Barwell, 2012). The teachers' role is to provide appropriate learning opportunities through language-responsive teaching. However, Ing et al. (2015) indicate that teacher practices do not have a direct impact on student achievement. The missing link is student participation (ibid.). By participating in rich discourse practices, students can gain a deeper understanding of mathematical concepts (ibid.). Teachers should encourage and support beneficial student participation in rich discourse practices in their classrooms in order to foster student achievement. However, O'Connor and Michaels (2019) point out that solely using tools is not sufficient, as they need to be embedded within the mathematical content:

> "[Talk moves] are not themselves the substance – the food – of instruction. [They] are the forks, spoons, and spatulas. Like the tools that skillful cooks must use, they are not the meal itself. The meal is the intellectual content, and the talk tools must be used in relation to ever-changing content." (ibid., p. 185).

This paper investigates which moves teachers use for teaching functional relationships in secondary school, and to what extent these moves promote beneficial student participation.

Theoretical background

Teacher moves for facilitating participation

Teachers have to fulfill various jobs in mathematics classrooms. Jobs are "the typical, often complex situational demands of subject-matter teaching" (Prediger, 2019, p. 370). Bass and Ball (2004) name several examples of core tasks and problems of teaching. For example, relevant in whole classroom discussions are: managing productive discussions, analyzing and evaluating student responses, and analyzing and responding to student error (ibid., p. 296). For coping with the jobs, teachers use pedagogical tools like tasks, activity structures and (facilitation) moves (Prediger, 2019, p. 370).

Such facilitation moves can be differently successful for promoting beneficial student participation. Bass and Ball (2004, p. 309) identify supportive teacher moves in this sense, e.g. "*moving of individual ideas into the public space*", "*helping those ideas be articulated in ways that others can work on them*", "*revoicing, with clarification, of student offerings*", or "*inviting peer-evaluation*". They emphasize that a prerequisite for these moves is that teachers are able to interpret student thinking and to link it to the current mathematical issue (ibid., p. 309). Their results apply especially for the topic of mathematical reasoning.

Although the study points out that the identified moves apply for the specific topic, many of the moves themselves seem to be topic-independent. They first have to be made concrete for the specific mathematical topic in order to be suitable for the current situation (for further examples of possible talk moves see O'Connor & Michaels, 2019). O'Connor and Michaels (2019, p. 185) describe their observation that some teachers picked up the suggested talk moves whereas other (in particular less experienced) teachers had problems. A possible explanation could be that less experienced teachers use the moves "robotically", which means that a revoicing move could be used when there is no reason to revoice (ibid.). In this case, the revoicing move is not suitable for the situation.

As a consequence, teachers need to command several moves, they need to be able to use a suitable tool that fits to the situation, and they need to be able to embed it in the specific mathematical content. This paper investigates which moves teachers use for moderating a whole classroom discussion on the mathematical content of 'meaning of functional relationships'. Additionally, the focus lies on how teachers link students' utterances to the mathematical learning goal of the lesson. Therefore, the paper first presents a conceptualization of understanding functional relationships and the intended learning goal of the teaching unit in focus.

Learning content: understanding functional relationships in contexts

The mathematical learning goal of the teaching unit in focus is the deepening of students' understanding of functional relationships in contexts. This paper refers to the conceptualization of the 'core' of the function concept (Zindel, 2017; Prediger & Zindel, 2017). Following Drollinger-Vetter (2011), understanding a concept appears in flexibly unfolding and compacting of comprehension elements of a concept. Zindel (2017) introduces the core of the function concept (Figure 1) that contains those comprehension elements that are important for every representation and every type of function in the middle grades (Zindel, 2017; Prediger & Zindel, 2017). There are three important insights concerning functional relationships (Fig. 1): (1) there are two involved quantities, (2) these quantities vary, and (3) there is a direction of dependency (one variable depends on the other variable). In situations where students have to identify the meaning of a functional relationship in a context, it is necessary to be flexible in unfolding and compacting the functional relationship into its smaller comprehension elements (Prediger & Zindel, 2017, p. 4165 f.).

As a consequence, it is important that teachers initiate and support the addressing of comprehension elements of the function concept as well as processes of unfolding and compacting. This requires moves like demanding explanations of the meaning of functional relationships (with regard to the involved quantities and their relationship). Thus, the main goal of the focused teaching unit is sensitizing for the comprehension elements from Figure 1 by contrasting and explaining the meaning of different functional relationships (Figure 2).Student participation is investigated by regarding the students' addressed comprehension elements within the classroom discussion.

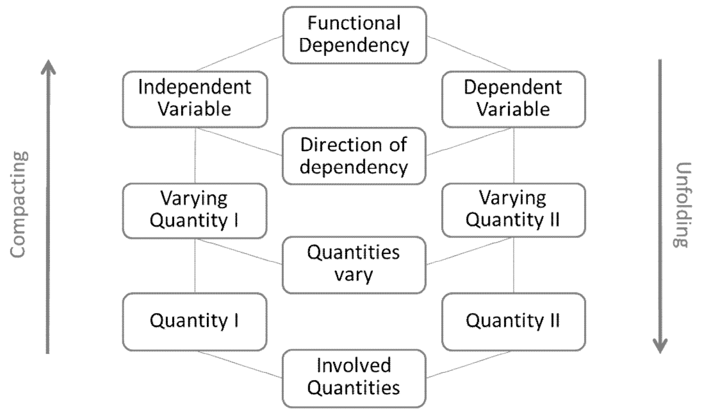

Figure 1: Comprehension elements of the core of the function concept (Prediger & Zindel, 2017, p. 4165)

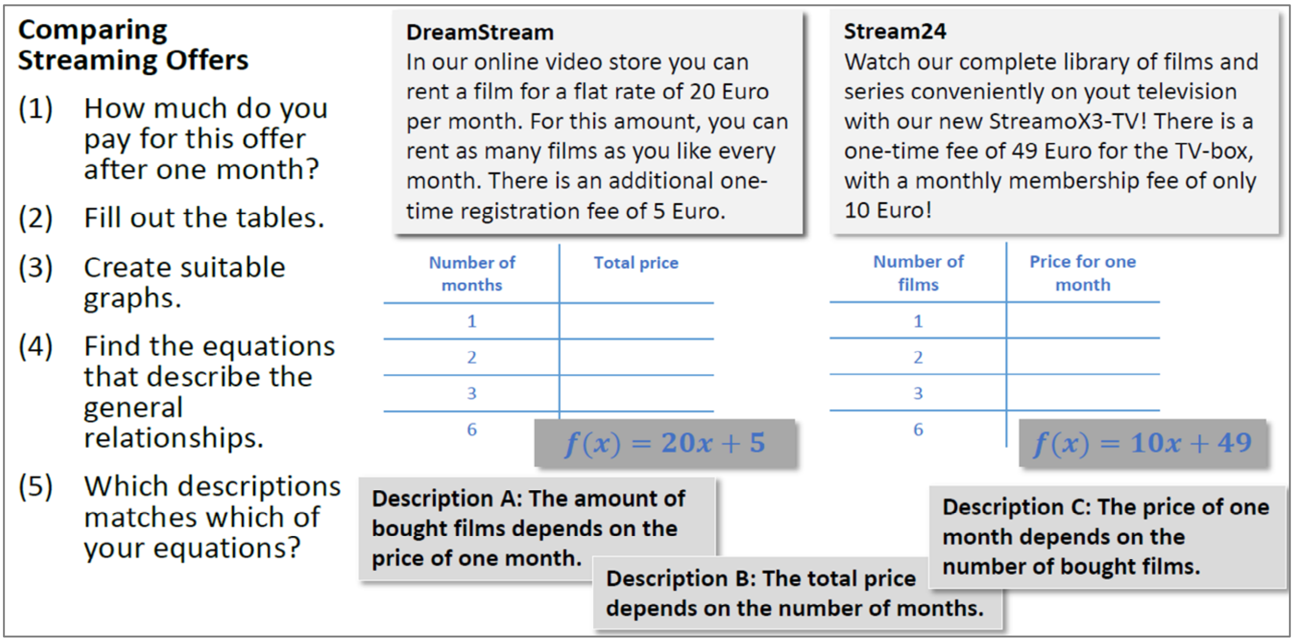

Figure 2: Identifying different functional relationships in streaming offers

Research questions

So far, the paper presented some examples for possibly supportive moves, as well as important comprehension elements of the function concept that form the focus of the teaching unit. The following research question can be derived:

RQ: Which moves do teachers use when moderating a discussion on the meaning of functional relationships? To what extent do their moves promote beneficial student participation?

Methods

Sampling. Overall, the data set consists of five teachers who were videotaped when teaching functional relationships in their grades 9. As this paper focuses on the whole classroom discussions after the students worked in groups, the videos were partly transcribed with regard to the whole-classroom discussions. In order to identify a broad range of possible moves, this paper adopts the approach of an exploratory case study (Yin, 2002). Two meaningful cases were selected for comparison that are distinct enough from each other to allow insights into their differences, yet not so far apart as to be incomparable.

Data analysis. The data analysis focused on the whole classroom discussion at the end of a group work. First, the teacher moves were identified by inductive category formation (Mayring, 2015): Excerpts from transcripts of whole-classroom discussions were collected and analyzed with regard to the teachers' demands and their way of leading the discussion. After that, the addressed comprehension elements were identified by a deductive-inductive analysis based on Figure 1.

Teaching material. Both teachers worked with the same teaching material (Figure 2) provided by the author. The students were divided into groups working on one streaming offer each before they compared their results and the different streaming offers in the whole classroom. The descriptions varied with regard to the involved quantities and the direction of dependency. This task aimed at increasing the students' awareness for these comprehension elements.

Empirical insights in two case studies

Case 1: Erin

Erin, the teacher, starts the discussion (#1) by the move *asking for the calculated result* of the first table row (Task 1a). She makes the communicative demand explicit by *demanding a full response*.

1	Erin	What is your result for the first task? How much do you pay after one month? Whole sentence!
2	Student 1	Well, for task 1a we have, in the first month you pay only 25 Euro.
3	Erin	25 Euro. *[writes 25 at the board]* Okay. *[…]* And what do you pay after two, three and six months? Student 2.
4	Student 2	Always 25 plus 7.
5	Erin	No.

Although the student answers in a whole sentence (#2), Erin refers to the calculated number only and records it at the blackboard (#3). Afterwards, she continues by *asking for calculated results* of the other table rows (e.g. #3) and *evaluates the students' answers only with "correct" or "no"*. She does not address any comprehension elements because she refers to the calculated numbers only. Later, a student gives a wrong result for the last table row. Erin reacts by *demanding the discourse practice of reporting procedures* (#13).

18	Erin	How would you calculate?
19	Student 4	130
20	Erin	130. What did you calculate?
21	Student 4	Simply calculated plus 65.
22	Erin	Is it correct?
23	Student 4	Yes. Because there are three, and two times three are six, and then simply two times 65.
24	Erin	Then look at the text again. *[…]*

In this excerpt, Erin *repeatedly asks for the discourse practice of reporting procedures* (#13, #18, #20). The student struggles because she seems to calculate two times the price after three months based on the assumption that it is a proportional relationship. Erin reacts by *asking whether this is correct* (#22) and the student reports her procedure in a more detailed way (#23). Nevertheless, Erin does not refer to the conceptual problem but gives the advice to look at the text again (#24). After another student has given the correct answer, Erin continues by collecting the results of the other groups in a similar way. Another problem when assigning descriptions to the function equations:

111	Erin	Does the amount of bought films depend on the price of one month? Student 12.
112	Student 12	I say no. We all have the same because the sentences do not make sense for us.
113	Erin	hmm *[doubting]*. Let's keep that as it is. *[…]*

One student explains the group's difficulties by saying that the descriptions do not make sense for them, showing that the students' difficulties can be traced back to unavailable conceptual understanding of a functional relationship. Nevertheless, Erin does not demand or promote any explanation of the functional relationships. Instead, she closes the discussion. Summing up, Erin goes through every task and only demands the discourse practice of reporting procedures.

Case 2: Natalie

Natalie starts the discussion (#1) by showing a graph (of the Stream24 offer) one group has prepared in the group work and *asking the other students connect it back to the alternative texts*.

1	Natalie	*[…]* Well, which streaming offer fits to this graph, what do you think? *[…]*
2	Student 2	I think that is the graph of the Stream24 offer, because you don't have to pay a registration fee or TV box at the beginning and it gets even 10 Euro more.
3	Natalie	Do you all agree?
4	Students	Yes.
5	Natalie	Makes sense, doesn't it? Good. The others who had this offer, too, did you draw the same graph? Who had this? Student 3, did you draw the same?

One student answers by referring to the comprehension elements of the meaning of the constants that he sees in the offer as well as in the graph (#2). Natalie does not evaluate this answer directly but calls on several students' opinions (#3, #5). Here, she does not explicitly address any comprehension elements. But in the next turn she *asks for the underlying assumptions* the drawer of the graph has made (#7).

7	Natalie	Yes, good okay. Well, what did the drawer took as a basis here? We all know how the Stream24 offer looks like. What did he consider with regard to the current films?
8	Student 2	That one doesn't watch any current films in a month but only old films.
9	Natalie	*[…]* Exactly. *[…]* They thought current films are too expensive, we just watch the classics. Good. So then there was a second task *[…]* You should set up an equation for Stream24. Which equation did you set up? *[…]*

After a student has given the correct answer (#8), Natalie *builds on the student's utterance to extend the main point* (#9). Then she refers to the task of setting up the function equations (#9).

10	Student 5	Erm. f then an equal sign. *[…]* in brackets x times four, right bracket plus 10.
11	Natalie	Some are putting up their hands already. Student 6.
12	Student 6	I would *[…]* exchange the four and the ten. So, f left bracket, x times 10#
13	Natalie	#go on first.
14	Student 6	Right bracket plus four. But the plus four ought to be written down only if you buy only one film per month.
15	Natalie	Hmm. That is not completely true, too. But erm, first it's Student seven's turn and then we come back to this.
16	Student 7	Left bracket, a times four, right bracket, plus c, because there are a films that have to be multiplied by four.
17	Natalie	Yes.
18	Student 7	So four Euro for each film and then plus 10 you have to pay for one month.

The students suggest two different variations for a function equation for Stream24 (#10, #12, #16, and #18). Here, Natalie *calls for different ideas and suggestions* again and thereby for students' participation (#11, #13, #15). Afterwards, she takes up one of the suggested equations and a*sks the others for the meaning of the equation* (#19). By that, she addresses the comprehension elements of the involved quantities (#19).

19	Natalie	What did Student 7 calculate here? For how many months does he calculate and for how many films? Student 8.
20	Student 8	Erm so for one month.
21	Natalie	And how many current films?
22	Student 8	Erm one.
23	Natalie	No.
24	Student 8	Well that is not given.
25	Natalie	Exactly. *[…]* That means you *[points to Student 7]* have set up a very nice equation for the case that I watch exact one month and I like to know how this depends on the number of films. But this is not what Student 4 has drawn, Student 4 assumed that he doesn't watch any current films. *[…]* And that is why we closely look at the first equation again.

A student suggests that the equation refers to one month and one film (#20, #22). Natalie *builds upon the student's statement* and *extends it by explaining the meaning of the two function equations herself* (#25). Summing up, Natalie initiates the discussion by using the not intended graph for making explicit the two possible functional relationships that can be seen in the Stream24 offer with respect to the different meaning of the variables. Thereby, she addresses the mathematical core of the function concept.

Comparing the cases

The identified moves and addressed comprehension elements are summarized in Table 1. Erin's move to go through every task and to ask for the calculated results addresses less comprehension elements concerning the meaning of the functional relationships. The overarching mathematical core the teaching material aimed at remains implicit. In contrast, Natalie commands moves that take into account topic-specific characteristics (e.g. clarifying the meaning of the variables). Besides, some of her moves seem to initiate students' addressing of comprehension elements. These beneficial moves are labeled as topic-specific moves in Table 1.

	Erin	**Natalie**
Topic-independent moves	• Going through every task and asking for calculated (numeric) results (#1, #3, #111) • Demanding the report of procedures (#18, #20) • Asking for and giving feedback on correctness (by yes/ no) (#5, #22) • Making communicative demands explicit (whole sentences) (#1)	• Calling on several students' results (#3, #5, #11, #15) • Giving face-saving evaluations (#15) • Extending student utterances in a general way (#13)
Topic-specific moves	• *none*	• Building upon a student product in order to initiate a discussion on the different possible functional relationships that can be seen in the Stream24 offer (#1) • Building upon students' utterances and clarifying the different meanings of the two suggested function equations for Stream24 (#19, #25) • Extending student utterances by focused and topic-related inquiries (#9)
Addressed comprehension elements by the teacher	• *none*	• Involved quantities (#9) • Involved variables (#19) • Functional dependency (#25)
Addressed comprehension elements by the students	• *none*	• meaning of the constants (#2, #14, #18) • involved quantities (#8) • involved variables (#16)

Table 1: Identified moves and addressed comprehension elements in both scenes

Conclusion and Discussion

Although they work with the same teaching materials, the two teachers moderate the classroom discussions in very different ways. Both teachers use moves that enable participation in a general way, but not every move is beneficial for student participation. Only one of the two teachers commands moves that initiate addressing relevant comprehension elements of functional relationships (building upon students' utterances and clarifying the different meanings in the function equations). These are moves that promote beneficial student participation whereas the other teacher uses moves that do not initiate beneficial student participation here (naming numeric results, reporting procedures). In this case, the mathematical core remains unclear as can be seen in the lack of understanding explicitly addressed by the students. Of course, the two cases can only give first insights in the field of teacher moves for teaching functional relationships, so that further research is needed. If the results can be proved for other cases, a possible consequence for PD-courses could be that teachers need more support in implementing general moves in a topic-specific way.

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