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Comparison of students' and researchers' choice of significant events of math lessons

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Considering the learners' perspectives on classroom teaching is central in our project 'AmadEUs', in which we work together with 79 students of four school classes in Austria and 23 pre-service teachers. In a first stage, we interviewed these students about significant events in math lessons they had just attended. In this paper, we analysed what kinds of events our students have mentioned and chosen and compared them with our (researchers') choice of significant events. While different groups of students tended to choose similar events, we observed differences between students' and researchers' choices of significant events. In a qualitative analysis, we tried to identify the characters of most commonly selected events by students in contrast to the teachers' and the researchers' selections.

Keywords: student voice, teaching practices, significant events, learners' perspective, secondary school mathematics

Introduction

Mathematics education is a complex network with several players involved, such as students, teachers, researchers and teacher educators, who prioritize different aspects of quality and therefore attach importance to different events during math lessons. Hence, one can understand and optimize teaching practice only through research that takes into account various perspectives, and particularly those of the learners as an essential part (see Clarke, Keitel, & Shimizu, 2006). Through giving students the opportunity to articulate their opinions, thoughts and feelings, valuable insights into their attitudes towards mathematics can be gained. Hence, listening to their voices has the potential to influence educators and policy makers (Mok, Kaur, Zhu, & Yau, 2013). This so-called Student Voice approach and some related studies will be further discussed in the theoretical framework.

One aim of our study is to explore which events of math lessons students consider as significant. The results do not only inform us about what kinds of events students consider as important for their learning, we might also get a clue about which events actually stay in their mind and in which events they might pay more attention to. This knowledge has the potential to influence and improve teaching practices (Huang & Barlow, 2013; Lee & Johnston-Wilder, 2013).

By comparing the choice of students to our own (researchers') choice of significant events (by that we mean short sequences of approximately 2-5 minutes) of the math lessons, we want to detect blind spots of typical researcher's views on mathematics education on the one hand. Through contrasting the two perspectives, we expect to maintain student-specific choices of concrete situations in the learning process, which can help teachers in their prospective lesson planning

(McIntyre, Pedder, & Rudduck, 2005). On the other hand, it is also interesting to discover events that are significant to researchers but not to students (and vice versa). For this, our study may give hints, where and in which way crucial points of lessons need to be made explicit to students, in case they do not attach importance to these points sufficiently by themselves.

Theoretical framework

Our study takes the perspectives of students into account. Such “Student voice” approaches have been of growing interest in the past two decades. Early work that has been conducted on the voice of students (e.g. McCallum, Hargreaves, & Gipps, 2000; Pollard & Triggs, 2000; Fielding, 2001) revealed the potential of listening to students in order to understand teaching and learning and making it more effective. In the course of this development, Robinson and Taylor (2007) aimed at theorizing student voice, carving out core values of student voice work. Flutter and Rudduck (2004) analysed different student voice initiatives and derived potential benefits to students, teachers and schools, including the potential to improve learning (as the participation of students might have a positive impact on their meta-cognitive development) as well as teaching (as teachers and researchers are provided with valuable insights).

As Allen (2003) pointed out, it took some time until students have been consulted to articulate their views about mathematics teaching and learning, but meanwhile several studies have been conducted in this field (e.g. Taylor, Hawera, & Young-Loveridge, 2005; Sullivan, Tobias, & McDonough, 2006; Lee & Johnston-Wilder, 2013; McDonough & Sullivan, 2014). While some studies concentrate on what students attach importance to in math lessons in general (e.g. Wilkie & Sullivan, 2018), only few studies deal with significant events of certain experienced math lessons. Of interest is the Learner’s Perspective Study (LPS), which has been designed to analyse and compare practices of mathematics classrooms around the world (Clarke, Keitel, & Shimizu, 2006). Within LPS, Huang and Barlow (2013) compared important events selected by students and teachers. They examined 15 videotaped consecutive mathematics lessons of one teacher, the corresponding lesson plans, teacher interviews and 30 student interviews. During the teacher interview, he described his intentions in the lesson, the important events from his point of view as well as his actions, thoughts and feelings during the important events. The two researchers analysed the data set in order to verify whether the important events identified by students coincided with the teachers’ intended important events within the lessons.

Using a slightly different research design than LPS, we seek answers to the following research questions:

What kinds of events of math lessons are significant for students and/or researchers?

By what criteria do students and researchers select these events and in what way do these criteria differ from each other?

Method

Teaching units: Four school classes (79 students) who visited our University were taught by pre-service teachers in the following topics: Percentage calculation (6th grade), introduction to probability theory (10th grade), combinatorics (11th grade), application of the differential calculus

(11th grade). Each class was divided into two groups. These 8 lesson sequences have been videotaped.

Identifying significant events of the math lessons: Right after each lesson, interviews were conducted and recorded among all students (groups of 2-4) to ascertain events that seemed significant to them (we used the German word “wichtig”). We do not predetermine the term “wichtig” as a survey construct, because we do not aspire to infer causal relationships to other constructs. In fact, we seek to learn more about what is important to students when reflecting on their attended math lessons. We thus chose the word “wichtig” out of a group of words with a similar meaning (such as “wesentlich”, “markant” or “maßgeblich”, which all translate to significant or important, respectively) for its easy comprehensibility and its openness for all kinds of aspects that could be meaningful to the students. “Wichtig” expresses that some aspect is of essential relevance (Duden, 2016).

We decided to use semi-structured interviews (Galletta, 2013) to reveal significant events from the students’ point of view. Our interview protocol consists of three segments: For the opening segment, we formulated two open-ended questions that stimulate students to talk about the math lesson they just experienced. The middle segment consists of more specific and structured questions directly related to our research that should jog the students’ memories as well as help them to reflect on different aspects of the lesson. These questions cover the scope of our intended meaning of important/significant events. In the concluding segment, students have to come to an agreement about the five most important/significant events.

In addition, we (as researchers) watched the complete video material (because we did not attend the lessons) and took notes of significant events. At the end of this process, each of us had to choose the five most significant events from his/her own point of view.

In order to conduct an analysis, assistants fragmented each lesson sequence into short scenes due to certain criteria (e.g. change of teaching method, change of subject, presenting or discussing a new example, etc.). Altogether, this procedure led to 221 scenes (for all lesson sequences). After our own selection of events (the researchers’ choice) had been completed, we evaluated the audio material of the student interviews in order to mark their significant events. Each scene was then labelled according to the number of selected events that coincide with that scene (at least partially). For example, the scene label *2R1S* means that two (out of three) researchers and one of the three groups of students selected significant events that occurred during this scene (see Figure 1 for a short extract of one lesson sequence). At this stage, we were able to analyse the data quantitatively and qualitatively respectively.

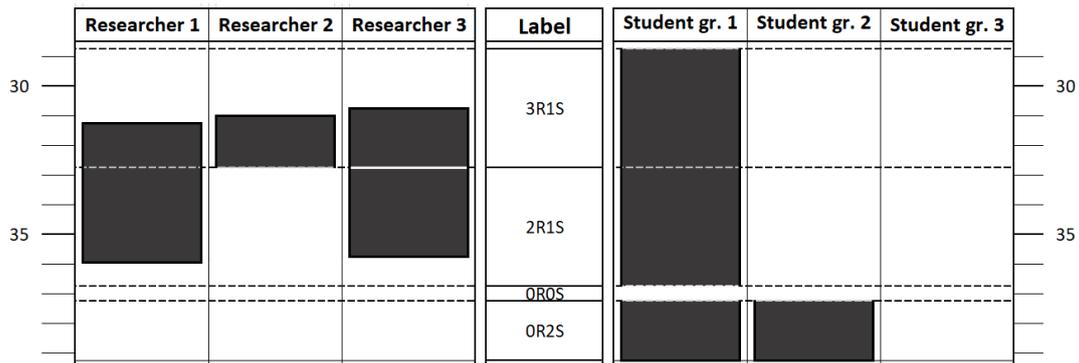


Figure 1: Scene labels according to selected significant events

Results

Differences in significance between students and researchers

In order to measure the disparity between researchers' and students' selection, we determined the difference of the number of researchers' and students' marks for each scene. While the difference is at most 1 in 75% of all scenes ($n=221$), we observed 15 scenes (7%) which have been found significant by either all researchers and no group of students, or vice versa. These scenes are of great interest. 85 scenes (38%) are marked solely by either students or researchers. We must mention that 42 of these 85 scenes are labelled as significant by only one group of students or one researcher, respectively.

In more detail, 23% of all scenes are significant for at least one group of students, but not for any researcher. The majority of these scenes belong to student-centred learning phases. Furthermore, students but not researchers highlighted many events assigned to group work phases and games (due to their active participation) as well as summaries. Students have predominantly chosen events in which they had fun, events that suited them as well as events in which they could easily follow, irrespective of the professional or didactical quality.

On the other hand, 15% of all scenes are significant for at least one researcher, but not for any group of students. Such scenes often contain mathematical errors of the teachers or didactical mistakes (e.g. confusing explanations, explanations that might lead to misconceptions, etc.) and have been commonly chosen by us due to the revealed lack of (pedagogical) content knowledge of the acting teacher. A small part deals with interesting procedures of the teachers that have been either considered as appropriate or inappropriate by us.

Qualitative analysis of a particular scene

For the following scene (which all researchers and students marked as significant), we go more in-depth into the corresponding justifications stated by students and researchers.

Combinatorics (11th grade), minute 63–68

Description of the scene: The teachers use this scene to sum up the content of the lesson. The graphic shown in Figure 2 is drawn on the blackboard to help students identify combinatorial

problems as either a variation, permutation or combination and to repeat the associated formulas which have been taught in this lesson. During that scene, one teacher confuses variation with combination and gets corrected by his colleague.

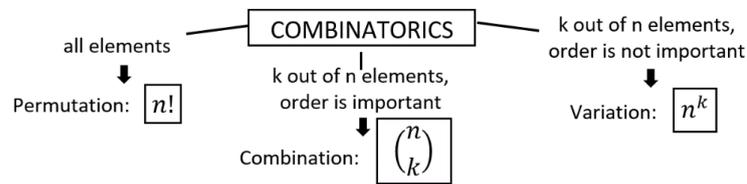


Figure 2: Decision tree

Perspective of students: All groups of students appreciated the summary as a ‘helpful overview’ and identified that scene as a key point. They described the provided graphic as ‘very good’, ‘well-structured’ and ‘easy to follow’. It also helped them to solve problems they had to work on after that scene. Furthermore, they liked that the teachers helped and corrected each other and got the feeling that errors are permitted.

Perspective of researchers: We observed several inaccuracies and errors. The teachers define the permutation solely by choosing all elements of a certain set. They do not mention whether order matters or repetition is allowed and even indicate once that the order does *not* matter:

Teacher: If I cannot deduce from the task that the order matters or that a subset is chosen, then it is always a permutation.

In their graphic, combination and variation only differ in the matter of the order. It is neither mentioned that combinations are without repetition nor that repetitions are allowed in variations. By saying, “We choose k out of n elements”, the teacher indicates that k cannot be greater than n in variations. A correct and thoroughly overview must include those two aspects (order and repetition) for each counting problem.

Further, the scene indicates a highly syntactical approach:

Teacher: No selection occurs; I just take all elements. I’ve only got an ‘ n ’.

Student: I see. This is a permutation.

Teacher: Yes, this is a permutation, because we do not have a ‘ k ’ [...] because I simply need one number.

Without being able to verify the criteria of a permutation, students give the correct answer, knowing that the formula of permutations (out of the three presented formulas $n!$, n choose k and n^k) is the only one that consists of one parameter.

Comparison and discussion: While all groups of students looked upon that scene favourably, we chose that scene due to the syntactical approach and inaccuracies/errors showing a lack of (pedagogical) content knowledge. As students do not know any other counting problem apart from those three presented in that lesson, the given overview is sufficient to distinguish between them, although misconceptions might result (e.g. that k cannot be larger than n in a variation). As the whole topic is new to them, they trust in the expertise of the teachers and are not able to identify

errors. Thus, they focus on the use of the summary (e.g. repeating the formulas), whereas we focus on the content quality. We agree that a summary of counting problems is a good idea, but the poor implementation has been decisive for our selection.

Discussion and conclusions

The results have demonstrated that the difference of the number of researchers' and students' marks for each scene is at most 1 in 75% of the cases, however, the reasons for choosing certain scenes are quite different, as we have shown in the above mentioned example.

While we focused on events that deploy the didactic strategies of the teachers or revealed existing or missing (pedagogical) content knowledge, the students concentrated on student-centred learning phases, summaries, quizzes and games. This emphasis on student-centred learning phases is in line with the findings of Huang and Barlow (2013) and Mok et al. (2013). Their interviewed students attached importance to seatwork and group work. Wilkie and Sullivan (2018) illustrated that students wish among others more such phases in their math lessons. In the present study, students described teacher-centred phases as 'conventional instruction', which could be a reason for choosing student-centred events. Being active is more meaningful and therefore more memorable to them. The findings of Lee and Johnston-Wilder (2013) confirm the importance of quizzes and games for students. In their study, students explicitly demand more interactivity, games and creative tasks. The significance of such events might issue from feelings of success (discover connections, find solutions to certain problems and so on) or emotional involvement. According to Huang and Barlow (2013) and Mok et al. (2013), students valued review and feedback parts as important. Those findings are also in line with our study: Students have chosen summaries as significant and valuable events (as has been shown in the qualitative analysis). However, our data reveals that the researchers did not mention summaries unless they included mistakes or highlights.

Contrary to our expectations and to the results of Mok et al. (2013), students barely talked about teacher explanations. This even holds true for some appalling explanations by the teachers that were not even mentioned by the students during the interviews, although some questions focused on teacher explanations. We conclude that the students did either not remember those scenes or did not attach any importance to them. In a certain way, their focus on methodical aspects of math lessons is understandable, due to students' less developed meta-cognitive skills and the fact that highlights during classes are kept in mind more strongly. These findings are in line with the study of Waldis, Grob, Pauli and Reusser (2010), who compared student ratings with class observer ratings of math classes and found differences between these two groups when rating cognitively activating instructions and the structure of math classes.

In cases where students and researchers selected the same events, different reasons were decisive. This is similar to the result of Huang and Barlow (2013), who obtained differences in students' and teachers' interpretations in such match cases. We presented an example, where students described the visualisation and the associated explanation as well-structured while we as researchers valued it as confusing and identified several content-related mistakes. This may be due to a certain inability of students to detect mistakes or to think about alternative approaches to particular concepts (Lee & Johnston-Wilder, 2013) while still being involved in the learning processes and not being able to

oversee the topic as a whole. Some statements expressed by students during the interviews hypothesise that they tend to evaluate the quality of explanations according to how easily they are able to solve corresponding tasks. This implies that their self-assessment relating to their mathematical understanding depends on (amongst other aspects) the tasks they need to solve.

For mathematics teaching practice, we can deduce that students obviously and understandably depend on the teachers' knowledge and the way content is dealt with in class. We have seen that they did not mention several inconsistencies or misleading actions of the teachers, which were obvious to us as researchers and teacher trainers, respectively. Hence, teachers cannot fully rely on students' feedback concerning content-related or didactical inappropriateness, they should – beside asking students for regular feedback – see to get feedback from experienced mathematics teachers or teacher educators (e.g. through job shadowing) in order to gradually improve their teaching practice.

It is essential for the learning process that students are aware of essential content points of the lesson (e.g. phases where concept formation and the development of basic mathematical ideas are in the centre of interest), but our study reveals that they hardly mentioned them nor valued many of them as important. According to Huang and Barlow (2013), the agreement on the importance of such events between students and teachers is necessary for effective learning. We deduce from our results that teachers have to emphasise these essential content points on a meta-level to be sure that the students value these events appropriately. Teacher training has to do its duty at this point by calling the teachers' attention to this problem.

What we can learn from the students' choices of events and the associated justifications is that teachers indeed should make an effort to include more student-centred and methodically varied learning phases into their math lessons (as they do have the potential to motivate students and to enhance their activity as well as their attention). However, it is crucial that there has to be a strong focus on the quality of the content promoted in these phases. As we have seen in our data, games and quizzes are popular among students, but it is difficult to get any content-related feedback to these events from them on the spot, even in cases where we have chosen the same scene out of misleading or confusing aspects. Hence, entertaining elements have the potential to inspire students and to stay in mind. However, they must not cover the content and the learning goals of the lesson.

Teachers can gain useful insights into their students' learning by knowing what classroom events they perceive as important, as they are then able to adjust their teaching practice in order to catch their attention and draw it to essential content points. In addition, a lot can be learned from students' justifications of their selected events as this has the potential to reveal – through further analysis – certain predispositions students have towards math lessons in general.

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