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When talking about media in primary school, often, one thinks of the use of computers during everyday classes every once in a while. When realizing that we live in a more and more digitalized world, this seems rather odd. The sole use of media in school is not sufficient to prepare children for a world that expects so much more. The fundamentals of computer science are strongly related to mathematics content and can therefore be linked to competences that children already learn today. The paper will present the evaluation of learning environments, developed with computer science content, to have a closer look at interactional processes that occur when working on a topic that is on the one hand strongly connected to e.g. mathematics but on the other hand fundamentally new for elementary school children and especially relevant in today's society. We will focus on co-cooperative processes and consensus and dissent.

Keywords: Computer science, interaction, mathematical competences, digitalization.

Introduction

Digitalization is a topic that almost every professional branch has to deal with. The problem is not that structures are changing and new or modified competences are required, it rather is a problem that children in today's primary schools in Germany are rarely prepared to sustain and work in a world where computing skills will be a needed in most branches. As terms like "media competences" or "media education" are watered-down (Krauthausen, 2012) understanding the underlying structures (e.g., logic, algorithms, programming, cryptography, data) is equally important. Most research projects that already exist, try to teach coding in a child friendly way (Garmann, 2016). It is essential to find a viable room where computer science contents can be worked on and looking at similar and equal competences, mathematics would be the ideal candidate for this. With this connection in mind we based our project on developing learning environments in the intersection of mathematics and computer science. We will not solely focus on content learning of mathematics and computer science but will have a closer look at learning in interactive processes because of our underlying understanding of learning as increasingly autonomous participation in negotiation processes.

Our research will focus on interactional processes and collective argumentations (Krummheuer & Brandt, 2001) in these mathematics/computer science learning environments. Krummheuer bases his research on mathematics content and it will be interesting to see how this theory is applicable to content material that is in many regards new to primary school children. Our view on learning in this regard is from an interactionist point of view. We look at how children negotiate meaning and focus on the interaction between them. The research question we are interested in also include these interactional processes, structures and negotiations of meaning when working on specific topics. According to Miller (2006) individuals that work in a group aim to solve dissents in their discourses. Different individuals bring different approaches and interpretations into the discussion. During collective argumentations, differences act as socio-cognitive conflicts (Miller, 1986), which induce further collective argumentations. Miller highlights that an ideal collective learning process requires a socio-cognitive conflict. He claims that to achieve collective learning, all individuals have to be aware of the ongoing conflict and a scheme of strategies has to be present for individuals to solve the conflict. In our research, it is interesting to see, whether

these conflicts, or dissents, are always present, and if so how it is treated by the individuals, and whether it is not rather a cooperative structure or a consent that fosters learning on the basis of a consent. For the purpose of this paper, we will narrow our research question down to focus on what roles the concepts of dissent and consensus in regard to cooperative learning play and how they influence the negotiation of meaning. In particular it is interesting whether a dissent can also be the basis to work onwards from or whether a working consensus is needed.

Our view on learning and research focus

Miller (1986) has developed a sociological theory of learning in order to distinguish it from psychological approaches of learning. This theory of collective learning processes of at least two individuals is founded on the thought that the learning of new basic theories in early development of a child is determined through interactive dialogic processes. Miller describes this as fundamental learning (Schütte, 2009). A core aspect of this approach is collective argumentations which Miller differentiates from "communicative acting" in the sense of Habermas (1985) that rests upon indisputability. Hereafter, the essential attribute of collective argumentations is the aspect of rationality. Fundamental mathematical learning occurs in collective negotiations about what is rational. Krummheuer and Brandt (2001) have created an interactionist theory of learning mathematics based on the theory of collective learning processes related to Bruner's (1983) approach of what he calls format. Based on this theory, the learning of mathematics can be seen as an increasing autonomous participation in collective argumentations that are produced and nurtured collectively by the group itself. Learning in this sense is subject-specific learning in and through interaction based on a social-constructivist understanding of learning resp. following epistemological approaches of symbolic interactionism (Blumer, 1969). Participants learn through participation in subject-specific interactions. These interactions occur when working collectively towards a common purpose (Borsch, 2010).

Working in smaller groups provides the advantage, that single children are not able to extract themselves from group tasks or discussions but rather that they are encouraged to participate. The foundation of learning can either be a dissent that has to be resolved (Miller, 2015) or a consensus (Krummheuer, 1992). Krummheuer also states that dissents do usually not appear in primary school as there are often not many possible solutions to discuss. As the topic of computer science is fundamentally new to primary school children it would not be surprising to observe dissents between the group members, as different perceptions and ideas come together. It is exciting to see how children handle these dissents. Another question would be whether a consensus has to follow from a dissent (Krummheuer, 2011). Traditional lessons in school usually try to avoid dissents but studies show that the accepting and resolving controversies can lead to better achievements with both high-performance and underachieving children. In addition to that, controversies foster acceptance and support between group members (Johnson & Johnson, 1986). Krummheuer speaks of the working consensus, a common denominator that serves as a basis for further collaboration and which is essential to continue. Possibly, participation patterns (Brandt & Tatsis, 2009), or special roles like the focal navigator who leads the group on a content basis (Schneeberger, 2009) can be transferred from mathematics to computer science lessons.

Connection of mathematics and computer science

Looking at today's primary school teacher education in Germany computer science as a subject is not an option to choose. Sometimes schools have a media competence program but the underlying content differs from school to school. During further training, some teachers can accumulate more knowledge on how to use media and teach computer science knowledge but this is a very limited path that is not available to everyone. Looking at other countries, computer science seems to be more deeply established in the primary school curriculum already. In Great

Britain, the new computing curriculum from 2014 clearly cuts the strings to training specific software and concentrates more onto programming and understanding information technology, as it is mostly comprised of computer science content rather than merely using technology.

Teaching computer science in primary school in Germany cannot be accomplished as a separate subject from day one, because of the already set timetable that has not much room for additional subject (except for extracurricular activities that do not reach every pupil). To prove its importance, it would be necessary to connect and integrate computer science into another subject. Although almost all subjects that are taught in primary school can be connected to computer science, mathematics seems to be the ideal candidate. Looking into the core curriculum one can observe that competences that are necessary to perform well in mathematics are needed in computer science tasks at well. Looking into the core curriculum one can easily identify connections between the competences in mathematics and computer science. The connections at the competence level that can be found suggest, that mathematics and computer science are built on a similar basis. Learning one could benefit the other. Regarding the mathematical competences of space and shape, we found that e.g. spatial orientation is a key competence when it comes to programming a robot. Movements have to be defined, obstacles have to be kept in mind and motion sequences have to be predicted. This is only one example to illustrate the overlapping of competences. It would be difficult to modify the existing mathematical lessons to include computer science content. Rather, specific learning environments have been developed to show that learning computer science topics nurtures the competences that are necessary for both mathematics and computer science. The learning environments should always foster discussions between the participants that will lead to fruitful outcomes.

CS learning environments in primary school - Methods

The underlying qualitative study is located in the interactionist approaches of interpretive classroom research in mathematics education (Schütte, 2009). The empirical foundation consists of videos of what can be seen as common group work processes in primary school with a new content. The content is new in regard to the situation in which it is embedded. Surely, the concept of algorithms and logic in general is also partly broached in mathematics lessons but the actual developing of the algorithms or logical reasoning itself inside of a new topic is something that primary school children, at least in Germany, do not do. To analyse the interactional units, we orientate ourselves by a reconstructive-interpretive methodology. To analyze the collective processes of negotiation, video-recordings of group work conversations were made, transcribed and subject to interactional analysis (among others, Krummheuer, 2011). We partnered with one primary school in Dresden that enabled us to work with 19 students from grade 4. The learning environments were designed to cover three sessions of 90 minutes for each topic. The learning environments were developed during one of the authors' empirical seminars for future elementary school teachers. The students in the seminar developed the first draft of the learning environments on their own. After a presentation and extensive reviews each learning environment was finalized into a researcher journal to hand to the children. The main topics are: logic (general and propositional), algorithms, cryptography, programming/robotics and technology. Of the three sessions, two sessions of 90 minutes are planned for the actual content-related activities and one session of 90 minutes reserved for documentation and evaluation of learning processes e.g. with a storyboard. The storyboard tool can also serve as an access to learning as it not only reviews what has been learned, it also enables the children to actively reflect on the content that they are working with. The tool of reflection therefore becomes a learning tool as well. The storyboard is also the ideal tool for the programming/robotics learning environment. The main goal after developing and building the robot itself will be to program its specific actions. It was important

for the learning environments to focus on interaction and talking between the participants as well as cooperative or co-dependent learning.

Each task should be designed in a way that fosters interactional processes between the participants as we focus on learning through collective argumentation and participation (Krummheuer, 2011). The primary task of every learning environment always is to get a first impression of what the participants already know (or think they know) about the concept. Very open questions like 'What does logic mean?' or 'When does a person have to think logically?' provide a wide variety of possible answers without any pressure for right or wrong. The focus here is not on content learning alone but rather on the learning that occurs between individuals whilst discussing and arguing about the specific topic since children learn through increasing autonomous participation (Krummheuer, 1992). This idea of learning can be transferred to the learning of basic competences in computer science. To build upon this concept, all ways of communication and interaction between the children have to be supported as much as possible. To ensure an efficient way to videotape the children working on the learning environments, we designed the environments to be worked on in pairs or groups of three, sometimes with a closing task, that included a larger group discussion in groups of up to six children. The learning environments that this paper will focus on are algorithms and logic. These have been specifically chosen because these are two learning environments that do not use a computer to work on computer science topics and competences. The children work on their tasks using pen and paper (or some other analogue material). It is important to understand that working on computer science does not always require a computer per se. The children did not seem to have a problem with the situation as no one complained about the lack of digital media during these situations. When thinking about this it seems quite obvious as the structure of an algorithm has to be learned before implementing it in a computer program, and this does not necessarily require a computer.

Observations and conclusions

To make first assumptions on dissent and consensus two short examples will be presented from the algorithm and logic learning environment. After learning what an algorithm does and discussing several examples, the children are asked to identify one algorithm that they already know from their mathematics lessons and write it down instruction after instruction. The hope here is that through actively discussing the structure of an algorithm the children can gain a deeper understanding of how the algorithm works. Most children use the algorithms correctly, because they know them and have practiced them, but when it comes to describing the structure, most children struggle to do so. The focus moves immediately to long arithmetic techniques and the children decide to work with long forms of calculation. Here, "long arithmetic techniques" will be used for written calculations with every interim stage clearly visible. The short version would be the mental process without any writing or if the child only writes down the Problem and the solution without any interim stages. The task is as follows: Can you find an algorithm in mathematics? If so, describe it step by step, so that a person that has no knowledge of the algorithm and its function can perform it. Test your algorithm with an example. The children first discuss what specific example they should use and here the first disagreement occurs:

Theo:	Let's say…500 minus 55
Ralph:	That is not the long way Theo, I can solve that easily in my head….445
Interviewer:	So what is the long way?
Theo:	The long way is when you have 345 divided by 7 and then you write down these numbers and underline them, then you write down the equal sign…

The children have to find an example to demonstrate the long way of addition. Interestingly Theo proposes an example, apparently not expecting that Ralph could see an example as unsuitable

(which is not possible, as the long form of any calculation can be done with every example). Ralph on the other hand considers the example unsuitable because, at least for him, it seems not necessary to perform the long way of the calculation because he can solve it mentally. For him, the necessity to perform this written version of the calculation seems to be strongly connected to his inability to do it in any other, shorter way as he dismisses the easier example. It could be interpreted that for Ralph the task has to have a certain complexity. Therefore, he proposes a much more complicated example (he even switches to division and not subtraction, although the full long form of division has not been topic in the classroom yet). Obviously there is a dissent, or according to Miller a socio-cognitive conflict, between the two pupils that has to be proceeded somehow. One possibility could be that the pupils discuss on eye level the different examples and argue whether one example would be more suitable than the other. As the overall situation suggest that an imbalance of power exists between the two children this possibility seems to be the least likely. In this example the conflict between the two pupils results in the search for a more complicated example and sets the standard for the rest of the conversation. Theo retracts after this excerpt and Ralph takes the lead. Theo does not even try to defend his proposition but accepts the proposal of Ralph. Ralph raises the bar for the entire task as Theo does not clarify that his example would be perfectly fine for the task. Regarding the whole situation, one can interpret that Ralph feels superior to Theo and he tries to impress his opinion without evaluating Theo's statements for correctness or suitability.

The second task is taken from the learning environment with the topic: logic. After being introduced to the topic and a first introductory task to think about what the term logic means, the pupils had to decide whether a statement is right or wrong (e.g. when the street is wet, it rained). They have to discuss the task and decide on an answer. The statement of this particular transcript is: If something is round it is not pointy. Right or wrong? The children then engage into a lively discussion, where they have to decide what qualifies as being round:

Lukas:	If something is round it is not pointy\ [reads]
	That does not have to be true\
Simon:	(It is not\) [laughs].
Lukas:	That does not have to be true maybe it is so to say a pointy circle\
Interviewer:	How does a pointy circle work?\
Lukas:	So. wait (4) [draws into his folder (see graphic, Figure 1]
Simon:	[looks into Lukas' folder]
Lukas:	Like this and so on and on \ [points at the drawing in his folder]
Simon	Yes, but if something is round [draws a circle into the air with his pen] so this here [points at Lukas' drawing] that is not round\ that is pointy\
Lukas:	Yes, it is roundish but if it is round then you are right\

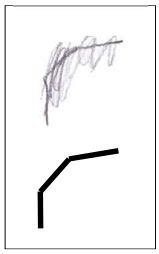

Figure 1. Drawing of Lukas

Lukas starts the discussion with his remark that it does not have to be true and elaborates that it could be something like a pointy circle. The "pointy circle" turns out to be a polygon, with angles larger than 90 degrees (see graphic in transcript). From his sketch, one could assume that he would

also agree to call something round, when it follows the shape of a circle (or circular segment) even though it still has vertices. The pupils then do not agree on whether this would qualify as a round object which results in a socio-cognitive conflict that pushes Lukas and Simon to argue collectively. The problem that occurs is to decide what the characteristics of a round resp. a pointy object are. In the end, they do not move on with a dissent as they try to reach a consensus because otherwise they would not find an answer to the question because they only have right or wrong as possible answers. To resolve this dissent, Lukas revises his opinion and proposes that his drawing would qualify as roundish. That is, not completely round and also not completely pointy. Both pupils communicate their view of the matter and in the end, find a solution that might not be accepted as a general truth but which can help them to answer the question, knowing that they could defend their answer if they had to. In comparison to the first situation, the children here seem to be on par. They find a solution to their problem through discussion, whereas in the first example one child behaves superior to the other and raises the difficulty of the task by relying on his own abilities and ignoring the insights of his group member.

Remembering the question of dissent and consensus it becomes clear that in task 2 (logic learning environment), the children start with a dissent that turns into a consensus as they both try to find a solution for their struggle with the term pointy. The children are not able to find a solution based on their disagreement and therefore create a new term for the object that they need to describe. Example one on the other hand has a power component that seems to put one student above the other on an intellectual level or at least one child puts himself above the other in diminishing the other child's answer as not suitable for the task although it would work as well as his own. This seems to eliminate the need for a consensus as the child in control dictates the terms for further discussion. The dissent is not a topic that is actively discussed but it remains in the situation and the children move on without resolving it. It remains the question whether this is still to be seen as autonomous participation and whether collective argumentation occurred or whether the children only moved on, on the basis of their different levels inside the group. It could be possible that a dissent that is not negotiated but resolved through retraction of one child and control of the other has to be viewed differently. The reasons for which this occurs should be analyzed more carefully to see whether the structure that occurs on the surface also represents the situation itself.

As for the research question, it seems that especially new topics that also connect to existing knowledge produce situations where dissents arise. The discussion takes part on a level that could also be part of a mathematics lesson but the basis is a computer science/mathematics learning environment which might have an impact on the view of the children onto the topic itself (e.g. the task to describe the algorithm step by step is a computer science problem that is not generally worked on in mathematics in primary school).

Since the analysis of the situations is still in progress and new situations are being taped, we will be able to identify similarities and describe the different situations of the pupils and their individual learning potential that occur during the group tasks. This will also benefit the understanding of dissent and consensus as the basis of collective argumentation.

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