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# **Dissent and consensus situational structures in interaction based on mathematics and computer science learning**

Peter Ludes-Adamy<sup>1</sup> and Marcus Schütte<sup>2</sup>

<sup>1</sup>Leibniz Universität Hannover, Philosophical Faculty, Hannover, Germany; peter.ludes-adamy@ifs.uni-hannover.de

<sup>2</sup>Leibniz Universität Hannover, Philosophical Faculty, Hannover, Germany; marcus.schuette@ifs.uni-hannover.de

*How exactly and under which circumstances does the learning of the fundamentally new occur? To focus on this question, learning environments with core topics of mathematics and computer science are examined. In the focus of digitalization, computer science and its connection to mathematics will play an important role in future curricula, making it an interesting object of investigation. Furthermore, at primary level, computer science topics are about to be included in every subject, including mathematics. The paper presents an ongoing study that examines, how the topic of computer science connected to mathematics learning can be approached in primary schools and what and how meanings are negotiated. The focus will be on the question, what roles consensus and dissent play in interactional processes of negotiation and how the learning of the fundamentally (Miller, 1986) new occurs in collective argumentation between pupils.*

*Keywords: Interaction, Dissent, Consensus, mathematics, computer science*

## **View on learning mathematics and the learning of the fundamentally new**

When talking about learning, we see learning from an interactionist point of view. Miller (1986) developed a sociological theory, where he focuses on collective learning processes of at least two individuals to distinguish himself from psychological approaches to the term learning. Fundamental mathematical learning occurs in collective negotiation processes (Schütte, 2009). On the basis of a theory developed by Krummheuer and Brandt (Krummheuer, 2007) learning in mathematics is seen as an increasingly autonomous participation in collective argumentation processes. Hitherto, these theories focus on mathematics learning. To extend the theories a topic with a close relationship to mathematics is chosen but which is fundamentally new to primary school children: computer science. Generally, primary school pupils in Germany do not have any structured knowledge about computer science concepts or the connected underlying mathematics. To understand how pupils can connect mathematics and computer science, one has to realize, how and where mathematics is related to this specific field. Mathematics can be connected to computer science on two levels: the content level, which includes the specific topics, such as algorithms, calculation, logic, as almost all mathematics content is relevant for computer science, and the competence level, which includes e.g. argumentation, modeling, communication. Especially the content-related mathematical competences can be linked to competences for computer science education in many ways (Ludes-Adamy & Schütte, 2019). This is of course true about many other domains as well, but the relation between these two topics seems to be especially interesting. The general idea is to transfer the findings in mathematics education to the learning of the - on primary level - fundamentally new but closely related topic of computer science and later on reconnect these new ideas to the learning of

mathematics to possibly pave new ways of learning mathematics content and develop additional approaches to mathematics education.

### **Working cooperatively**

The approach to cooperative learning is based on the ideas of Johnson and Johnson (1999). They named three organizational types of lessons called individualistic, competitive and cooperative. The first two types place the individual in the center of action, where no or negative interdependence occurs. The last structure, the cooperative one, follows the idea that pupils cooperate in a way that the group, as well as the individual are responsible for the successful handling of the task, which is called positive interdependence, as the different members have to rely on each other's individual work, although it seems difficult to provide students with such a task and keep them inside this working scheme. The study tries to connect interdependencies with dissent and consensus, which possibly arise from negotiation processes where socio-cognitive conflicts appear (Miller, 1986; Nührenbörger & Schwarzkopf, 2010). Thus, different interactional structures might emerge from these specific situations that can be identified and structured. When working competitively or cooperatively different consensus and dissent situations arise on the basis of interpretational differences. On the basis of these, new mathematical meaning can be negotiated at the least, in a situational frame. The research question that will now be focused in this paper is how situations in which dissents and consensuses emerge are structured when primary school pupils learn a subjectively new topic (Schütte, 2014) and negotiate and construct computer science and mathematics meaning collectively.

### **Methodology**

Learning environments in the intersection of mathematics and computer science with the topics logic, algorithms, cryptography, programming, binary code have been designed over several semesters, working closely together with students and teachers. The tasks themselves are designed closely to the concept of natural differentiation (Krauthausen & Scherer, 2014), although it became apparent that this premise is rather difficult when trying to convey fundamentally new content and there is little previous knowledge that can be activated. The children work on the tasks in groups of two to four. The data for the analyses originates from two pilot studies that have been run in small groups (11 and 13 pupils) in grade 3 and 4 and two main studies that took place with a larger number of pupils (48 and 47) in grade 4. The situations are recorded outside the usual lessons within the scope of a project week where the focus could be put solely on our learning environments. The recordings are transcribed and analyzed using methods of interpretive classroom research, primarily, interactional analysis (Schütte, Friesen, & Jung, 2019). The students that supervise the situations can provide help to the pupils if needed but are advised to maintain a low profile and merely observe if possible.

### **Tasks and analysis**

The data shows different interactional structures, that will be described as dissent/consensus situational structures in the following. These can be differentiated according to the initial interactional relationship between the individuals and the emergence or transformation of the final interactional structure. The individual cases will be defined when describing the corresponding situation. One type has been described previously by Ludes-Adamy and Schütte (2018), where a *dissent-consensus-*

*situational-structure* emerges in which the collectively originated dissent transforms into a collectively negotiated consensus to construct situational-dependent new mathematical meaning (Krummheuer, 2007). The following examples will show other situations that indicate other interactional structures as well. The first task is a logical structure, with different statements that lead to logical conclusions. The 11 statements are as follows: 1. All numbers of this puzzle are integers. 2. The number D is 9 times A. 3. The sum of G and J is 100. 4. Three times D is G. 5. The fifth part of the number E is J. 6. H is half of D. 7. B is double of D. 8. If I subtract 2 from the quotient of E and J, I receive C. 9. The digit sum of all numbers is F. 10. I is double of C. 11. D is a number of the nine times table and less than 30. (Solution: A=2; B=36; C=3; D=18; E=230; F=62; G=54; H=9; I=6; J=46).

Kai	well, it is best, it is best . actually it is best/ well it can be nine . actually it is best if we get D
Jonas	is it now twenty-seven or eighteen . D/..
Kai	because with D there are a lot of tasks
Jonas	yes but then we have to find out B first
Kai	do we want to do the A eh do we want to (5) do we want oh man that is difficult(12)
Teacher	what did you want to say/ do we want/ ..
Kai	here . well (incomprehensible) . write down the eighteen for D
Jonas	(a moment) D/ . but it could be twenty-seven or nine as well
Kai	I mean to try out
Jonas	moment (9)
Kai	so do we want to write down eighteen for D/ .
Jonas	mhh let's try ..
Kai	so eighteen .. so and A ehh . no that doesn't work
Jonas	wait . a moment/ .
Kai	because when this is eighteen A must be two
Jonas	B is that . a moment
Kai	no look, when you look at the second
Jonas	H is half of .. D so it must be fourteen
Kai	no .
Jonas	if it is eighteen . .
Kai	nine /
Jonas	so .
Kai	H is nine if it is half of eighteen
Jonas	moment yes the eighteen is right . otherwise this would be . ehm . the sixth task one would not be able to solve it
Kai	so eighteen is right/
Jonas	yes

**Figure 1 Transcript Kai & Jonas**

Throughout the task, Kai and Jonas cooperate and have a relatively good fitting to each other's ideas. A working consensus (Schütte et al., 2019) seems to emerge, in which the two boys freely interact with each other, without ever leaving the working consensus. Kai's first utterance shows a logical deductive conclusion as he proposes to find the number D, because it is used in many other statements. He seems to understand that the possibility to find a successor increases, if a number that is often used in other statements is known. Jonas does not explicitly agree, but he seems to accept it as a good suggestion as he immediately proposes two possible suggestions for D. The two pupils show an

almost perfect cooperation. They work together without specifically dividing tasks among themselves or discuss their collaboration. It seems a little bit confusing to follow their discussion, but they never seem to lose their goal out of sight. Kai and Jonas cooperate and deduct logically that eighteen can be the only possible candidate for D. In this first example, a general *consensus-situational-structure* seems to prevail throughout the cooperation. A *consensus-situational-structure* would be characterized through an interactional process, wherein the contradictions and clashes are so minimal that one would not recognize a general dissent. We call these small clashes *micro-dissents*. A *micro-dissent* is seen as a turn in a conversation, where one individual question the utterance of the other implicitly through short questions or injections but does not change the flow of the idea. The emerging idea is changed very subtle through these interjections and the outcome can be seen as a more solidified solution.

Another example of the same task will show a different situational structure. It is taken from a group of four girls who seem to be at different mathematical skill levels but try to work together. As they are discussing but do not pick up each other's inputs immediately, the conversations often stall, and the supervising student has the feeling that she needs to support through statements or help. This rather destroys the aspect of cooperative learning as the teacher takes all hurdles out of the way.

Lisa	I start. I would say we start with that G and J are simply fifty
Eva	so
Anna	no, because it also could be twenty and eighty
Lisa	Yeah sure, but how do you want to start . other than with that number . nine
Anna	Yes, then let's start with twenty and eighty or with seventy and thirty
Lisa	I don't care but we have to agree on one #
Eva	D is a number from the 9-series
Anna	or with forty and sixty or with thirty-five
Lisa	ten
Lisa	I would say we start with ninety and ten and then twenty hm no twenty and eighty
Anna	She just said something
Eva	D can be nine or eighteen or twenty-seven
Teacher	Well that is a nice overview of numbers . with those, you can #
Anna	Yes right, the nine, the eighteen and the twenty-seven
Teacher	mhm (affirmative) (5) you could fill it in for a start what you think what it could be
Lisa	so well/ . fill in what/ whatever
Eva	D
Anna	So are there any more information about D
Anna	yes three times D is G . mh that means one of these numbers has to be divided by three
Lisa	Wait, what should I put in?
Eva	For D you can write nine, eighteen and twenty-seven
Anna	yes both all of them (7) mh . here three times D is G that m e a n s . mh no idea
Eva	B is the double of D . H is half of D
Anna	H is half of D B is double of D but we don't know what these are
Teacher	Then let us think . think . if H is half of D then have a look at the numbers what the half was
Lisa	look . nine and half of that is three
Anna	point five but they have to be integers so nine
Eva	what/ eighteen only eighteen works with seven only eighteen works so it is eighteen because only eighteen works [all of them start to write]
Teacher	very well

Figure 2 Transcript Lisa, Eva & Anna

The girls all offer different ideas and they try to act upon those inputs. As the conversation seems to stall, the teacher helps. She suggests that the girls write down their possible answers. Lisa and Anna do not quite seem to understand what they are supposed to write down but Eva sums everything up after the teacher interjects a second time. It seems that Eva has more of an overview on the situation than the other two girls. Unfortunately, the teacher intervenes in a way that makes cooperative learning hardly possible as it destroys the exact situation where Anna and Lisa would eventually require help from Eva to understand what she already might have grasped. Eva seems to have a general idea and she could probably explain this idea to the others, but the teacher moves all hurdles out of the way. Whether the two other girls now have a better understanding of the situation or the solution does not become clear. Through the teacher's interference, the framing differences cannot be coordinated (Schütte et al., 2019). This is a difficult situation to observe real interactional processes between the children as this crucial point is covered up. As the pupils interact with each other and seem to try to at least pick up the sentences of each other but do not interact on a level that resolves their differences, we would describe this situation as a *consent-dissent-situational structure*. Although this denomination seems odd, it shall describe a situation, where the individuals are working collectively and interact but cannot align their framing differences to reach a working consensus.

A further example that illustrates a third type of situational structure is taken from the Algorithms learning environment. After learning what an algorithm is and how it is connected to computer science the pupils have the task to find algorithms in mathematics. Most groups decide to use long forms of calculation that always follow a specific pattern. Here the connection of computer science and mathematics becomes very obvious as the concept of an algorithm exists in both fields equally but at least in German primary education the term algorithm and its meaning are not taught to the children explicitly. Theo and Karl try to find an example to illustrate the long form of a calculation before writing down a general algorithm.

Theo	Let's say . . . 500 minus 55
Karl	This is not the long ways Theo, I can do it in my head . . . 445
L.	What is the long way/
Karl	The long way is when you have 345 divided by 7 and then you write down this numbers and underline them and then write the equal sign
Karl	Now, I say 345 divided by 7 then it works.

**Figure 3 Transcript Theo & Karl**

Theo proposes an example that is perfectly suitable to write down the algorithm for a long form of calculation. Karl on the other hand thinks that only an example, where the long form of calculation is compulsively necessary (mentally), qualifies. Therefore, he does not consider Theo's example. An implicit dissent emerges that is not resolved in any manner but rather kept on a meta level. The basis for moving on is just Karl imprinting his opinion as correct onto the situation. This would be what we would call a *dissent-situational-structure*. This structure would be characterized through a dissent, that is not resolved in any way and exists throughout the situation, either implicitly or explicitly.

The tasks on logic and algorithms had a closer relation to conventional mathematics lessons as they deal directly with numbers, although being situated in a computer science context. To see how pupils interact in a new context and to elevate the theory from purely mathematics education we will look

at a situation where the pupils talk about programming, a for primary school children fundamentally new topic, where specific framings were not yet differentiated. Programming melts computer science and mathematics together, as almost always calculations and mathematical thinking is required to write code and on the other hand, computational thinking, which is a core element of programming, is necessary and helpful in mathematics. Theo and Maria, who have never been taught about programming other than perhaps in their everyday language, talk about possibilities to program a microcontroller (Calliope Mini), that has been specifically designed for primary school children. They utter their ideas what programming is and what to do with the calliope. They have a laptop with the programming environment where visual code blocks can be linked together to create a working program. Elements that cannot be connected will not connect to each other. The pupils can therefore find out on their own what elements fit and how they interact. Theo and Maria test the programming surface with a trial and error method. The task is to try to create the code for a self-chosen program. They decide to write a program that makes the calliope play different tunes when touching the corners.

Maria	Let's use the element that makes sound. The calliope can make a sound when pushing a button so you can play music
Theo	But we can use the corners then we can make more sounds
Maria	Yes but we can use the buttons and make music
Theo	Yes but there are only two and then we only have two sounds
Maria	I use the buttons . . so 'if button A is pressed' play note c . . okay . . then 'if button A is pressed' play note d . . we can play Alle meine Entchen
Theo	No that is all wrong . . how is the thing supposed to know what to play . . you always say button A
Maria	yes first c and then d that is how the song starts
Theo	but it doesn't know when . . we cannot use the button more than once
Maria	why/ yes we can
Theo	no we have to use different buttons but we have two only . so let us use the corners there are four corners then we can play four notes
Maria	I don't know what you mean . you do it then
Theo	Okay . If corner 1 is touched play note c (7) if corner 2 is touched play note d (5) and so on (finishes for the other two corners) but we only can play now four different notes that is not enough for the song but we can play another song
Maria	But it does not work again only once . you made a mistake
Theo	no . what no that is awkward . no i don't know
Maria	let me try
Theo	alright have a look

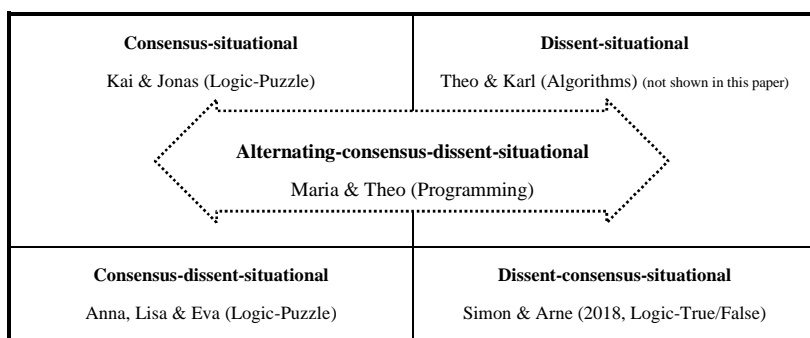
**Figure 4 Transcript Theo & Maria**

Maria and Theo have a dissent on what method would be best. Maria tries her solution with the buttons but according to Theo makes a bad engineering decision as she assigns different tasks to the button. Theo tries to explain his thinking which he does very well. In this situation Theo seems to be willing to work cooperatively. He does not only present his idea, he also explains why Maria's idea is, in his eyes, less suitable. Maria on the other hand is not convinced of Theo's criticism and tries to stick with her solution until she finally suggests that Theo does what he wants. Then, when Theo hits a hurdle himself, Maria also suggests he might have made a mistake and wants to try and help which Theo accepts. The classification of this situation is rather difficult. The first impression is that this is a *consensus-situational-structure*, as Theo is willing to take Maria's ideas and tries to

cooperatively tackle the mistakes she makes. Maria’s unwillingness to accept her mistakes and work together with Theo to come to a joint solution on the other hand would be more than a *micro-dissent*, as the general idea of the solution does not move forward. This situation seems to undergo a certain transformative process as it inherits marks of both the *consensus-situational-structure* and the *dissent-situational-structure*. This could imply, that dissent and consensus situations that are negotiated working a fundamentally new topic are rather harder to be resolved into a permanent working consensus. In comparison to the other situations, where mathematics itself was more dominant and obvious, the pupils here have no previous knowledge on no general idea so it could be harder for them to reconstruct each other’s ideas and articulate possibly helpful utterances. as the pupils have not yet developed framings of computer science meaning for themselves and therefore cannot follow the other’s ideas. We would therefore classify this situation as an *alternating-consensus-dissent-situational structure*.

Relating back to Johnson and Johnson (1999) different basic forms of cooperation can be identified that describe different positive interdependencies between pupils when working on the fundamentally new. Thus, these different interdependencies have varying influences on the learning opportunities of the new. Currently, the situations are examined to see, how these basic structures form patterns that can be found throughout the situations can be categorized into a descriptive system, to find out in what way dissent and consensus and their resolution can build the basis for the negotiation of computer science/mathematics meaning and through this provide a basis for learning opportunities of the fundamentally new within this domain. Especially the more computer science related task of programming suggests, that the cooperational aspects between the group members seem to faint, when the individual itself has to cope with sharpening framings for themselves about the new content and therefore struggles to reconstruct the other one’s ideas.

To this point, the situations that have been presented can be brought into a schematic. We could reconstruct four different structures:



**Table 1 Dissent/Consensus-situational structures**

Further analysis will show, whether the situational structures that could be identified here, are also prevalent in other situations what their specific characteristics are and whether the finding of the fluent alternating structure is restricted to fundamentally new content.

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