ENHANCING CHILDRENS' ARGUMENTATION SKILLS IN PRIMARY SCHOOLS USING DIGITAL LEARNING TOOLS – INTERPRETATIVE ANALYSIS OF A FIRST DRAFT LEARNING ENVIRONMENT

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Within the project "Prim-E-Proof", digital media learning environments (Open Source Applets on Tablet PCs) are designed. The aim is to support argumentation and proving skills through the iconic and interactive visualization of reasoning processes in primary school. The focus of the project is on supporting classical teaching and learning processes with digital learning environments. In this paper selected scenes of the argumentation process of two pupils using a first draft learning environment (Platz, 2019) are analysed using interpretive methods.

Keywords: Educational Media, Primary Schools, Argumentation.

INTRODUCTION

> *"[…] The marginal place of proving in elementary school is seriously problematic. There are at least two reasons for that. First, elementary students are deprived of opportunities to learn deeply in mathematics. Second, when students ultimately encounter proving in secondary school or university it feels alien to them rather than a natural extension of their earlier mathematical experiences at elementary school."* (Stylianides, 2016, p. 1)

To foster a proof understanding the project "Prim-E-Proof" investigates the basics of proof understanding to derive conclusions for the proof understanding in higher education. That is why it aims to go beyond the mediation of argumentation competences in Primary School. But is this possible? Asking the same question as Stylianides (2016): "As these young children engage in mathematical reasoning, how does that activity connect to and prepare them for understanding proof in more advanced mathematics, a challenging topic even for older students and adults?" (Stylianides, 2016, Foreword). Pedemonte (2007) derives, that a structural change is required for the construction of a deductive proof, that is from abductive or inductive steps to deductive steps. A first draft learning environment using digital media was developed and tested in an empirical pilot study (Platz, 2019). The result was, that we did not succeed to awaken a need for proof (Kothe, 1979) in the pupils using this learning environment. Therefore, it was not possible to reconstruct a structural change for the construction of a deductive proof (Pedemonte, 2007). Nevertheless, a thorough analysis of the argumentation process of the pupils who participated in the study can provide indications for the optimization of the learning environment. In the present paper selected argumentation sequences of two fourth grade pupils are analysed using interpretive methods.

OBJECTIVES

The aim of the overall project is to create learning environments to support argumentation skills through the iconic and enactive visualization of reasoning processes. A central media aspect is to make the handling with teaching and learning material computer-detectable and thus, to infer optimized learning environments. The focus is on supporting classical teaching and learning processes in primary education with both digital and non-digital learning environments. As a first step, arithmetic proofs are focussed e.g. the sum/ difference of an even/ odd number and an even/ odd number is even/ odd. The objective of this paper is to give an interpretation of the argumentation process of two pupils while working with the first draft learning environment (cf Platz, 2019). For this purpose, digital learning tool specific patterns of action and opportunities (as well as risks) for promoting learners' reasoning skills are identified.

THEORETICAL BACKGROUND

For the analysis of students' proof and problem-solving activities exist several findings and theories. Selected theories are presented below and interpreted in the light of the specific form of support for such processes through digital learning environments.

Proof and Reasoning

Reasoning is not a new phenomenon and has been scientifically studied, especially in the recent century. A peculiarity of reasoning in elementary school mathematics lessons is that arguments are not just recited by a single person to justify their opinion. Rather, all learners are "usually involved in interaction processes that produce an argument in the entirety of their actions" (Krummheuer & Brandt, 2001, p. 18, Translation by the authors). Different structural schemes are used to analyze arguments (Budke & Meyer, 2015). In this article, argumentation processes will be represented in a model which is a combination of the approaches of Toulmin (1958), Toulmin, Rieke and Janik (1979), Miller (1986), Aberdein (2005), Pedemonte (2007) and Reid, Knipping and Crosby (2011), see Figure 1 (cf Platz, 2019). Toulmin's layout (1958) forms the basis of the developed model. Toulmin himself applied his layout to mathematics (cf Toulmin et al., 1979) and Aberdein (2005) applies Toulmin's layout to multi-step proofs. Over and above that Toulmin's model can be utilized as methodological tool to compare proof and argument (Pedemonte, 2007). To enable to grasp the entire process of argumentation and proof development, the refutation of arguments needs to be involved (Reid et al., 2011) as well as the structure of the argumentation process (Miller, 1986).

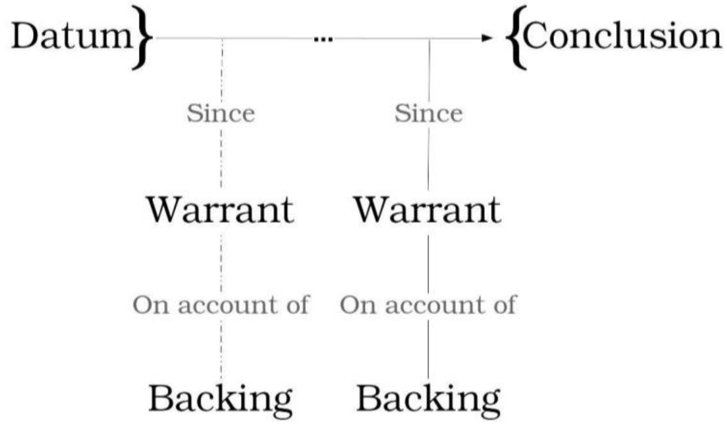
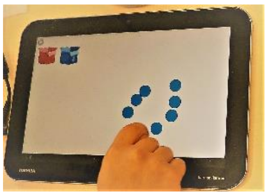


Figure 1. General argumentation scheme (cf Platz, 2019); the diagram can be read like a timeline from left to right; the dashed lines mark refutation trials of the assertion

Digital Learning Tool



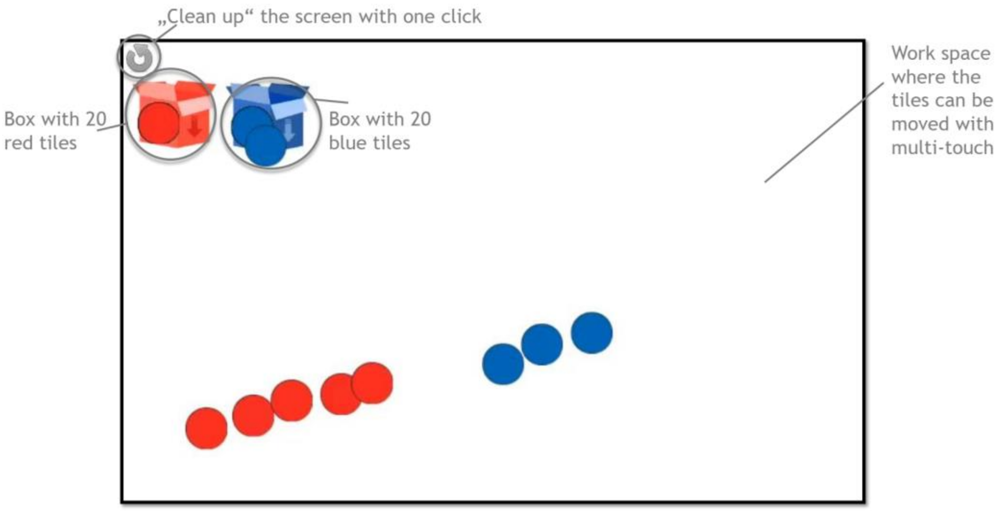


Figure 2. Child working on the freely available "(Reversible) Tile Applet" (http://www.melanie-platz.com/WPA/) and Screenshot of the Applet with explanations of the functionality.

The developed digital tool "(Reversible) Tile Applet" (see Figure 2) is developed for Tablet PCs and requires a browser which allows for multi-touch (e.g. Firefox). In contrast to existing apps and applets with tiles, no structuring aids are given in order to ensure a certain openness of the use of the applet. The applet can thus be used in the function as a medium of argumentation and proof. Due to the two-dimensional screen, the tiles cannot be stapled or lifted up. The current version of the applet acts almost as substitution of analogue tiles and can therefore be classified in the first step of enhancement referring to the SAMR-Model (Puentedura, 2010). Compared with analogue tiles, the organizational handling of the applet is more suitable for everyday use as it can be quickly provided and disposed off and single tiles cannot disappear (cf Platz, 2019). In contrast to real material, a modified applet would allow to generate any number of tiles. This would offer the potential to be used as a fact in a chain of arguments: No matter how many tiles are additional created to the existing one, the total number is always even. As the number of tiles increase, pairs of tiles can always be formed. In the learning tool used in the study design, only 40 tiles (20 red, 20 blue) were made available to the pupils to avoid the distraction of the pupils due trying to generate the most tiles possible and not working on the task given to the pupils. This concern can be supported by the reaction of one pupil in the test group: "You have to do that with more tiles. Because 40 is, we can already do it, we already count up to one million. These are too few then." Nevertheless, due to the potential of this feature of an arbitrary number of tiles, it needs to be tested in further empirical studies if these concerns are justified. Furthermore, a central media aspect shall be to make the handling with teaching and learning material computer-detectable and thus, to derive optimized learning environments. Multi-touch-"gestures" can be made detectable with the help of digital media, and automated evaluation and help selection are supposed to be provided. The idea is to support on the one hand the teacher by receiving feedback on the individual learning process of the pupils and through decision support on the when and how to start a discussion in a classroom context supporting argumentation processes. On the other hand, the pupils are supported through individualized task and support design and tailored help suggestion. With implementation of these functionalities, the first step of transformation according to the SAMR-Model (Puentedura, 2010) can be reached, which is modification, i.e. the technology allows for significant task redesign and enables other possibilities to handle heterogeneity in a school class. In order to optimize the developed learning tool and the learning environment, Design Science research is performed which is grounded in the philosophy of pragmatism (cf March & Smith, 1995). The Artifacts are the developed learning environments applying digital learning tools to support argumentation skills in primary school.

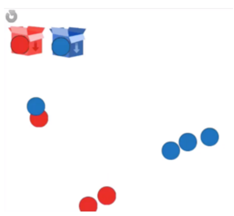
STUDY DESIGN

An empirical pilot study on the first draft learning environment (Platz, 2019) was performed with a fourth-grade school class of a German regular school containing 23 pupils (aged 10-11 years). The school class was separated into groups of six or respectively five pupils. Three tablets were made available where pupils worked in groups of two using one tablet and discussing their ideas and results. In each of the four cases, one group of two pupils of the three groups of pupils was videographed and the tablet screen was screen-casted, both with audio recording. Due to the teacher, the pupils had experience with working with analogue tiles and they knew how to control a tablet PC, but they had never worked with the applet or on proving tasks. A worksheet was given to the pupils: http://www.melanie-platz.com/ES_1/Task_even-and-odd.pdf. The main task the pupils were concerned with in the learning station is the following: *If you add two odd numbers together, you always get an even number. Is that correct? Give reasons!* An example on how a preformal proof for the task above could look like is made available at the following link: http://www.melanie-platz.com/ES_1/Preformal-Proof_even-and-odd.png. Each group worked on this task for 20 minutes. The recorded material was transcribed and sections were extracted, where information on the argumentation process could be discerned. In this paper, we take a closer look at selected scenes of the argumentation process of the two pupils Liam and Veit (names changed for data protection). The analysis of the data serves the purpose of reconstructing the arguments of the learners (user perspective). On the basis of the use by the learners, optimization possibilities for the learning environment can be determined in a next step (developer perspective). In order to reconstruct the user perspective, the transcript sections are analyzed with the help of interpretive methods (eg Bauersfeld, 1980, Voigt, 1995) with regard to argumentation structures.

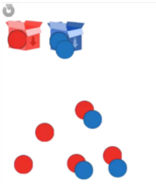
EMPIRICAL RESULTS

Scene 1

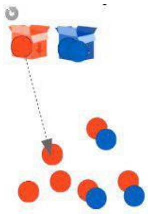
In the following scene Liam and Veit work on the given task: *If you add two odd numbers together, you always get an even number. Is that correct? Give reasons!* Right before the beginning of the scene, the two students decide to edit the task 5+3. The following dialog starts:



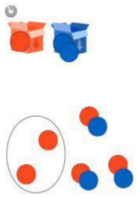
1 Liam: This can be put away. (*puts the blue tile on the upper left side back in the blue box. Afterwards, Liam shoves the remaining red tile next to the other red tiles. Hereafter, he creates two more red tiles and also shoves them next to the other red tiles*) first like this and then- (*Liam pairs each of the blue tiles to a red tile. Therefore, he rearranges the order. Two red tiles have no corresponding partner.*) Two remain, again even! (*laughter*)



2 Interviewer: Exactly, that is, what can you do with those two?
3 Veit: // Put away?
4 Liam: Another pair! //
5 Interviewer: Another pair, exactly!
6 Veit: Red and Red.
7 Liam: Red. (*creates another red tile and pairs it with one red tile*)



8 Interviewer: Ah, no, you do not have to put another one, this is already a pair.
9 Liam: Oh, I see.
10 Interviewer: Or?
11 Veit: Yes, because we could do it like this and this (*shoves the two remaining red tiles together like the other pairs*)



12 Interviewer: Okay, great!
13 Veit: We could also put this away. (*shoves a red tile in direction of the red box*) And just get a blue one, works too (*shoves the red tile back to the other red tile*).
14 Interviewer: Okay, exactly

Liam shows a structured approach in turn 1 ("first like this and then"): First, the task is illustrated color-coded with the tiles. Then, corresponding pairs of blue and red tiles are formed. For the remaining red tiles, Liam uses the quantity to support the statement that an even number is the result. At the request of the interviewer (Turn 2), Liam expresses the possibility of pairing the remaining tiles (Turn 4). Veit responds and gives permission to pair up two red tiles (Turn 6). Liam uses this option to create a new red tile (Turn 7). Why did Liam create a new red tile in Turn 7? One possible interpretation is that Liam has already accepted the fact of the even result and now wants to increase the red summand to show the phenomenon of the even result for arbitrary odd summands. However, in contrast to his procedure in Turn 1 he does not explain this and the interpretation is not confirmed in the following turns. Probably opposed to the creation of new tiles, Veit explicates his idea of pairing in Turn 11, as hinted at in Turn 6: The two red tiles can be easily paired and no more tiles need to be created. This procedure is accepted by the interviewer. Therefore, and according to interaction patterns in primary school (cf. Voigt, 1995), the argumentation process ends. In this scene, the phenomenon formulated in the theoretical background can be observed: arguments are manifested in the interaction by several learners (Krummheuer & Brandt, 2001). In the present scene, facets of an argument are taken up and modified by interactants and altogether an argumentation chain manifests itself in the conversation. Since, interactants refer to (suspected) rules of the other one: Veit seems to assume Liam's rule of pairing: "pairing is only possible from blue to red tiles" in Turn 13 and therefore probably explains his approach from Turn 11 with the explication that one can also replace a red tile with a blue tile.

The reconstructed argumentation process can be represented in the presented argumentation scheme, see Figure 3.

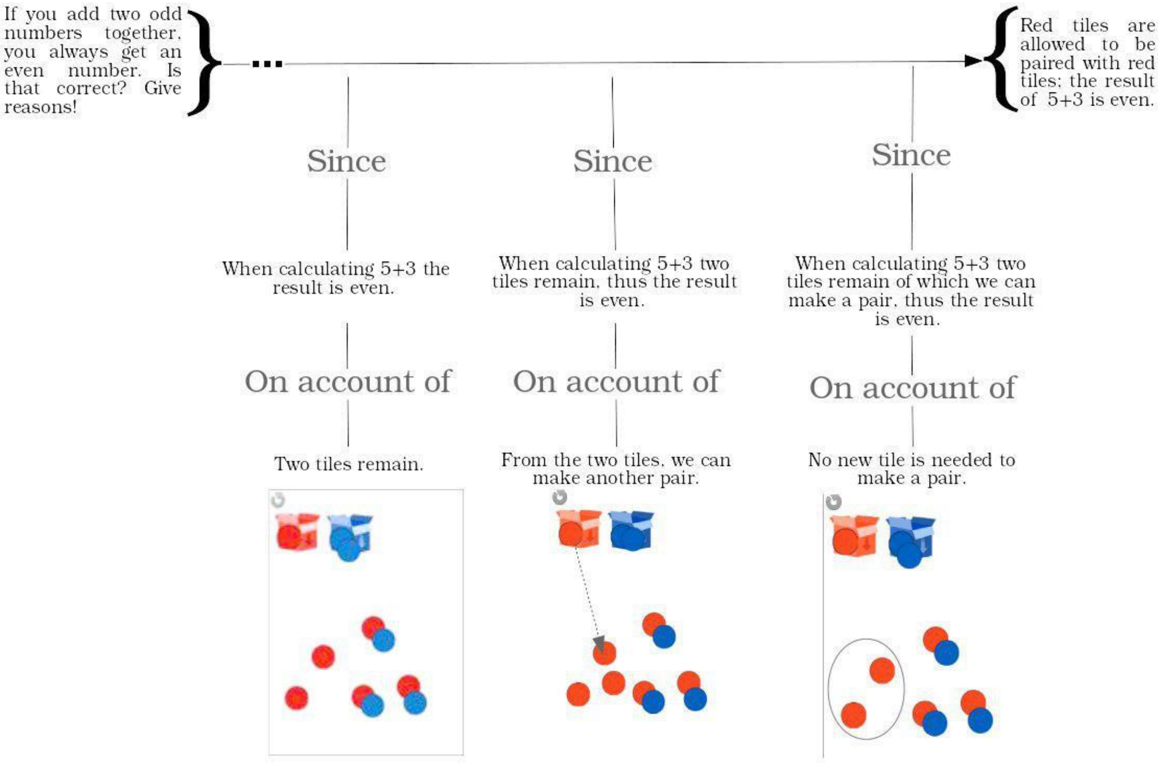


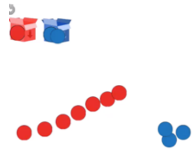
Figure 3. Representation of selected scenes of the argumentation process of Liam and Veit; the diagram can be read like a timeline from left to right; screenshots with markings visualize the action of the pupils while speaking (cf Platz, 2019)

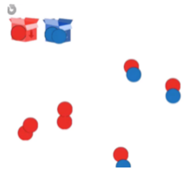
Scene 2

Immediately following the first scene, the dialogue continues as follows:

15	Interviewer:	then maybe just try with a (.) larger number so with (.) seven plus.
16	Veit:	uh
17	Liam:	//Five.
18	Interviewer:	Then maybe seven plus three // or something like that.
19	Veit:	seven plus eighty

20 Interviewer: Try seven plus three, if this (.) what happens then?
21 Liam: Seven three.
22 Veit: Well ten.
23 Liam: Three blue ones.
24 Veit: // Ah
25 Liam: Three four // five six seven plus three. (...) Look seven plus three. (..) Oh, I have to allocate it, like that (..) that and again like that and that (inc.) that that, okay, we have it!





26 Veit: Yes.
27 Liam: Easy!

Here is a much faster procedure than in the first scene to watch. Liam seems to have accepted the rule that red tiles are allowed to be paired with red tiles, and is quick to do that in Turn 25. Striking is the repeated use of the structured procedure from the first scene: First, the tiles have to be laid in sorted order by color. Then, the pairing has to be done. Perhaps Veit would like to do a complicated task and is under-challenged (Turn 19) but does not adhere to the requirement of adding two odd numbers, this interpretation is supported by quickly naming the even result ten in Turn 22. Ten is an even number, why should we now deal with this, the solution is clear. Overall, the argument from Scene 1, developed in the interaction and accepted by the interviewer, is correctly applied to a new task.

CONCLUSION

In our analysis facets of the (scientific) correct argumentation in the interaction have been worked out and the developed argumentation scheme has been successfully applied to the presentation of the interpretively worked out results. Likewise, possibilities for a generalization of the utterances of Liam (Scene 1) and Veit (Scene 2) have been identified. Some questions require further processing in the research project. Thus, Liam and Veit do not fully exploit all the possibilities to support their argumentation: For instance, the fact that a larger number of tiles (up to 40) can be generated in the developed app is not applied to Liam's and Veit's argument. This seems to be a problem of domain specificity (cf. Carrraher, Carraher & Schliemann, 1985 for pupil's handling with analogue manipulatives): which backings of arguments are supported by the tools offered? Which not? The orientation of learners to several options of backings seems to be a very important matter, since digital tools allow other possibilities than analogous ones. In a next step the developer perspective will be focused in order to derive optimization measures for the applet and the learning environment on the basis of the reconstruction of the user perspective presented in this paper.

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