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Parent-child cooperation in mathematics learning: Insights into maths-experience days

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Considering the fact that the influence parents have on their children's mathematical development is unavoidable, it should be less the question whether parents should participate in their children's mathematical education, but more how their participation could be incorporated more consciously. This issue becomes even more crucial with regard to secondary school mathematics. In this paper, one approach is presented, namely a family math in which parents and their children get the opportunity to deal with mathematics in problem-based discovery learning environments together as a team. The focus of this paper lies in the investigation and characterisation of parent-child cooperation in the course of the first workshop of the project, as well as factors promoting such cooperation or hindering it.

Keywords: Parental involvement, secondary school, cooperation, problem-solving.

INTRODUCTION

The critical role that parents play in their children's educational development in general and specifically in mathematics is undeniable (Desforges & Abouchaar, 2003). Parental beliefs about mathematics, its teaching and learning, emotions regarding mathematics or parents' mathematical competencies, to name just a few factors, come together to diverse influences on their children's mathematical education. What is more, parental participation in mathematical learning activities seems to decrease with their children getting older. In this context, Eccles and Harold (1993) mention, among other reasons, a change in parents' views of their competences to help their children with schoolwork as they enter higher school grades. In particular, with the switch from primary into secondary school, in Germany at the beginning of the 5th grade, mathematical contents start to become more and more unfamiliar for parents. Whereas

they could rely on being an omniscient answerer or the conveyer of knowledge in earlier school years, parents ultimately need to shift roles in order to further support their children regarding mathematics. Besides mathematical contents, parents may also feel that current methods of teaching mathematics may differ a lot from those they experienced in their school years (Eccles & Harold, 1993).

All in all, the conditions for parental support in their children's mathematical education change fundamentally in the course of secondary school years. Therewith, new challenges but at the same time new possibilities for parental involvement in their children's mathematical learning emerge.

INVOLVING PARENTS IN MATHEMATICAL EDUCATION

Initiatives for parental integration in their children's mathematical education often consist of one-way transmissions of information and materials from schools or other educational institutions. However, drawing on the social constructivist view, learning is not a simple process of transferring information, but involves an active social interaction. The emphasis thereby lies on learning as an ongoing process in activity-based learning situations with meaningful purpose (Vygotsky, 1978). In this context, findings from a project called MAPPS (Math for Parent Partners) indicate that giving parents opportunities to actively construct their own understanding of mathematical concepts provides an indisputable foundation for their work with their children. Moreover, research results of this project imply that the nature of interactions that parents developed with their children might be even more relevant than their ability to help them with specific content (Civil, Guevara, & Allexsaht-Snider, 2002). These findings emphasise that it is not only necessary to introduce parents to current math-

emational concepts in an active way, but also to foster parent-child interactions in mathematical contexts.

Since in secondary school mathematics parents' knowledge advantages decline, the foundation for parent-child interactions in context of mathematical problems change. Following the idea of a "community of learners", one goal is that parents and children work together with everyone serving as resources to the others, with varying roles according to their understanding of the problem at hand (Rogoff, Matusov, & White, 1996). This concept goes hand in hand with a cooperative learning approach that constitutes a foundation from which parent-child interactions can be fostered in the context of secondary school mathematics. In this sense, we understand parent-child cooperation as one main feature to describe the nature of parent-child interactions in mathematical learning situations.

Guided by the concept of dialogic learning, conversations in a cooperative learning approach should follow an egalitarian dialogue where different contributions are taken into consideration according to the validity of their reasoning instead of the position of power held by those who make the contributions (Flecha, 2000). Thus, in order to foster parent-child cooperation, it is essential to create a learning situation in which parents will not automatically act as the conveyer of knowledge, but rather become a learning partner for their children. This speaks for a concept with open-ended and problem-based discovery learning situations (Bruner, 1961) in which parents and their children get involved with a mathematical problem in a self-directed way (Hmelo-Silver, 2004).

Considering the demand to integrate parents more actively in their children's mathematical secondary school education, the questions arise: How does the cooperation of parents and their children in the context of a discovery learning situation work out? Which facets promote a parent-child-cooperation, which not?

METHODOLOGY

The project and its participants

One possibility to investigate forms and conditions of parent-child cooperation in an open-ended and problem-based discovery learning situation is provided by a family math project, called maths-experience-days. This project started as a pilot project in the school

year 2012/13 with parents and their children from a 5th grade (10–11 years old) of a German higher-level secondary school, a so-called gymnasium. The project workshops lasted three to four hours and took place in the school building on Saturdays, hence outside of schooldays. The participation was on a voluntary basis.

In the first workshop, which builds the basis of the results presented and discussed, twenty-two families participated with both parents appearing in five cases. Hence, a total number of twenty-seven parents attended the first workshop, among these seventeen mothers and ten fathers. The parents' ages varied between 36 to 52 years old. Due to incomplete data sources only the data of twenty-five could be taken into account in the research presented.

The families participating in the project live in rather high socio-economic conditions. With respect to parental educational backgrounds, it can be noted that every parent has a school leaving-qualification. All in all, seventeen parents achieved the general qualification for university entrance, of which fifteen of those parents obtain a university degree and two did an apprenticeship. Moreover, seven parents achieved a subject-related entrance qualification. Two of those parents finished a polytechnic degree and five an apprenticeship. Only one parent achieved an intermediate school-leaving certificate who did an apprenticeship as well. The occupational fields are diverse and range, for example, from business management, law to medicine, natural sciences or social professions. Each and every parent has a job at the time of the survey.

The first station of the discovery journey – content and structure

According to the above-mentioned general conditions for the learning environment, a didactical reduction of the mathematical content seems to be reasonable. This concerns the complexity of the problem presented to the parents and their children at the beginning of the workshop (see Figure 1).

„A friend of mine, let's call him Harry, used to be a paper boy when we were a bit younger. His job was to deliver a free regional newspaper once a week. He loved working in the fresh air and meeting all the people living in his delivery district. However, there

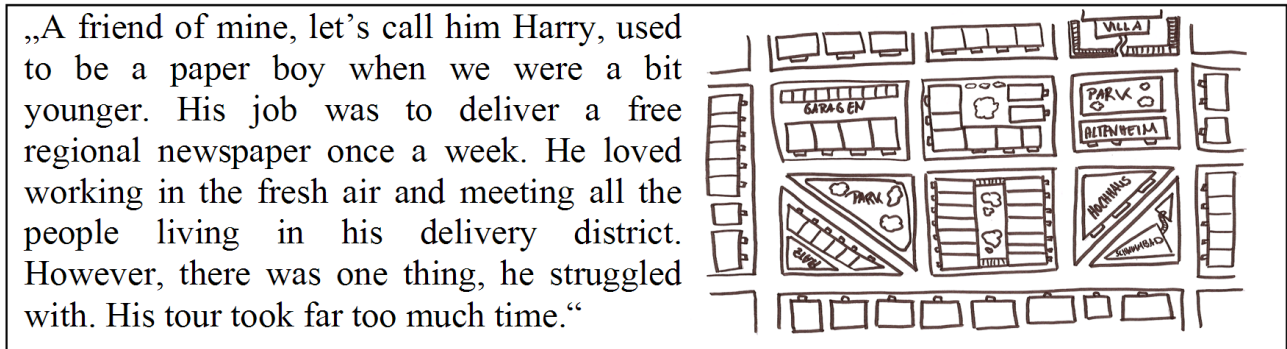


Figure 1: Problem and Harry's delivery district – working material

was one thing, he struggled with. His tour took far too much time.“

Due to the requirements for autonomous learning and performance of the parent-child teams, the role of the workshop coordinator rather consists in encouraging cooperation by scaffolding strategies like recruitment, direction maintenance and frustration control than providing scaffolding methods with stronger content-related guidance (Wood, Bruner, & Ross, 1976). In the need of content-wise support, parent-child teams can draw on different hint cards according to their progress in problem-solving. Those hint cards are constructed on the basis of scaffolding methods like reducing degrees of freedom by simplifying the task as well as accentuating critical and relevant features or, at last, demonstrate the solution itself.

The phase of the problem investigation is structured through the cooperative learning method “think-pair-share” (Sharan, 1994), which particularly shall subserve parent-child cooperation. First, parents and children think about possible approaches to solve the paperboy's problem for themselves and, then in pairs (parents and children) exchange their idea is, carrying them forward together. At last, the ideas are collected and discussed in the whole group.

Data sources

We have several data sources at our disposal that play a role for the analysis and hence the presentation of the results. While considering multiple data sources, we draw on an approach that is characterized by triangulation of data (Schoenfeld, 2008).

Before the first workshop, and again after the last workshop, parents are asked to answer a questionnaire containing both open and closed items. Besides personal information like age, gender, school educa-

tion, vocational training, and occupation, the questionnaire consists of parental beliefs about mathematics considering both cognitive and affective aspects as well as their personal reasons for participation.

Likewise, data concerning the process of working on the problem in the course of each workshop is collected. Here, reflective journals are used which have become an accepted method for qualitative researchers to gain insights into their participants' thinking (Mewborn, 2013). On the one hand, parents and children document their mathematical considerations during the problem investigation. On the other hand, the reflective journals are used by parents and children at the end of each workshop. In order to encourage reflection, guiding questions are displayed which address their experiences, difficulties that occurred as well as strategies to overcome them and new insights that parents and children gained during the workshop.

Besides parents' and children's journal entries after the first workshop, the results presented in this paper are based on field notes taken during and immediately after the workshop by the coordinator.

Analysis

The experiences of parents and children during the first workshop indicate diverse aspects for an analysis, all of which cannot be taken into account. In this paper the focus lies on the analysis of data referring to parent-child cooperation during the problem-solving process.

On the one hand, parents explicitly referred to forms of parent-child interactions throughout the entire reflective journal from which the nature of their cooperation could directly be derived. On the other hand, some parents did not mention their children or the

work with their children at all. Thus, cooperation patterns were implicit. In order to interpret those journal entries and moreover validate interpretations, they were matched with other data sources like the corresponding journal entries of their children and field notes taken by the coordinator of the workshop.

The analytical framework for the open data sources is informed by the principles of qualitative content analysis (Mayring, 2010). First, hints on parent-child cooperation were independently selected from the reflective journals by the authors and significant themes identified with the goal to induce a categorisation of parents' cooperative behavior. Second, interpretations were compared between the authors and discrepancies were discussed. A category formulation was determined and checked in a final sifting through reflective journals. Finally, in due consideration of all data sources, parents were assigned to one of the inductively developed categories.

RESULTS AND DISCUSSION

To understand the whole picture, some facts need to be pointed out before the discussion of results. First, the sample consists of parents with a high socio-economic status and therefore is of limited representativeness. Second, they participated in the family math project voluntarily. Consequently, the sample is selective by its nature. However, taking into account all of the conditions, the data still allows some interesting insights.

The findings show that parents can be assigned to one of two categories: *parents as learning partners* and *parents as learners*. The two notions of parental roles are similar to those used by (Civil, 2001), although the conditions of parental integration are different from the MAPPs project with regard to the direct involvement of children in our project. While the first category *parents as learning partners* could be observed for thirteen parents, six parents were assigned to the category *parents as learners*. Another six parents do not give any information about the parent-child cooperation and could not be coded.

In the following, we first briefly describe the meaning of the two categories and use excerpts from parents' and children's journals to exemplify our shared understanding of the categories. In the course of exemplifying the categorisation, some aspects with a posi-

tive effect on parent-child cooperation, but also some with a negative effect are pointed out. We indicate the authors of the answers by M for mother, F for father, and C for child, combined with a respective number.

Parents as learning partners

In the category – parents as learning partners, the parents are open to cooperation with their children and accept the children as “equal partners” (M20) in the discussion, like it is intended by the above-mentioned dialogic learning approach. Here, parents often emphasise the positive experience of this cooperation. In what follows, we give an example of a statement on the parent-child cooperation experienced as positive:

[The process of solving the problem was] constructive, through cooperation with my child. [...] and we perfectly complemented each other. [...] My child approached the problem with more enthusiasm and curiosity than me. That made me happy. (M8)

Additionally, field notes give a closer insight in the kind of cooperation between mother and child. During the problem-solving process the mother took a step back, gave her daughter room and let her explain her approaches and insights first. Here and there, the mother summarised partial results and asked some crucial questions. Thereby the mother-child team got further in their problem-solving process and at the end reached an overall solution. It moreover is interesting that the daughter shares this positive experience of working together with her mother, as she expresses:

We solved it [the problem] in teamwork. That was cool. (C8)

In this context, one identifiable factor for the positive experiences regarding parent-child cooperation is that the mathematical problem is not only unknown for the children but the parents as well. Moreover, since the problem is open-ended, both, parents and their children could contribute to the problem solution in their own ways. They could even approach it on an equal footing. However that was not the case for every parent-child team. In a few cases the fact that the problem was an unknown riddle for both, parents and children, did not work in favor of parent-child cooperation, but against it. Those cases are discussed below in the part of *parents as learners*.

Other parents emphasise the good parent-child cooperation during the workshop while confirming the stressful relationship to mathematics learning situations in context of school mathematics at home, like for example:

[...]. I especially do find the cooperation between child and parents very refreshing. Away from the mathematics-homework-problems to a “voluntary” learning and approach to mathematics. [...] There was no “school pressure” as probably usual. It simply was fun and had a good result. (F11)

The child as well remarks the positive parent-child-cooperation but furthermore values the mathematical context away from numbers and calculations like it is excessively stressed in school.

I liked it because it was something new and in maths with Miss H we always do calculations. (C11)

Indeed, arithmetic commonly builds a focal point in school mathematics. With that, this comment points out that an open-ended and problem-based discovery learning environment is a fruitful opportunity to gain positive new experiences with and diverse insights into mathematics, which are often missed out in school contexts.

Other parental journal entries clearly show that a cooperation does work, when parents do not take over a dominating role, a role of being master of knowledge, but become a learning partner for their children, sometimes on an equal footing. This aspect is for example reflected by the following parental expression:

At times the cooperation was good, when we came closer to the solution and respected each other as equal “providers of ideas / partners”. There also were moments when my child lost interest [...] when the solution of the problem at times receded into the distance. (M20)

One main problem becomes apparent with this quote. Sometimes children get set back by occurring difficulties in the mathematical problem-solving. In this case parents should support their children more actively in order to overcome the difficulties together and refocus. Such situations in the workshops constitute an opportunity to impart methods and techniques

to parents for supporting their children in a critical mathematical learning situation.

Parents as learners

In the category – parents as learners, it becomes obvious that parents are keen to learn mathematics for themselves. They are fascinated by the mathematical problem at hand and take the opportunity of getting fully absorbed in the task. Being completely engaged in their own problem-solving process, they lose sight of their children and do not enter into cooperation with them.

One mother describes in detail her work on the mathematical problem, exclusively using the first person. For example, she comments on her thinking process, occurring difficulties while working on the problem, and finally concludes with the following statement:

I would have liked to cooperate more closely with my daughter. (M7)

Not only the field notes point in a similar direction, but also the child comments on the workshop exclusively using the first person. This further strengthens the impression that no cooperation took place.

Other responses give a closer look into forms of cooperation between parents and children. One father points out, that he would have liked to accomplish the problem solution on his own and hence is not content with *his* work. He solely refers to his child in one line with the coordinator and the other participants when asking for exchange as he got stuck in his own problem-solving process:

Thinking into an impasse, solved it via exchange (with child, coordinator other participants). (F22)

However, the field notes confirm the impression of the father deepened into his own problem-solving process and completely forgot his child over it. The child himself tried to get some glimpses at his father’s problem-solving process, asking for insights, but was on his own for the rest of the problem-solving process. This impression is again strengthened by the child using only the first person in his journal entries, not referring to his father at all.

The following example, where the child together with father and mother took part in the workshop,

is another illustration for the category of *parents as learners* where a competitive thought is decisive for a lack in parent-child cooperation. While the father describes his point of view in a concise way, the mother is more detailed and discusses her despair in the problem-solving process, but also her ambition to overcome her difficulties on her own. The problem-solving process of this family can be best described as competitive, which can be confirmed by the following mother's statement.

What my husband is able to accomplish, I need to accomplish as well. (M24)

Nevertheless, she clearly expresses her wish for more cooperation in her further remarks.

[I would have liked] that we cooperated more closely – instead of everyone for himself. (M24)

The child strengthens the impression of competition and the lack of cooperation by writing the following:

Nasty that dad always was the first one to find out everything. (C24)

Taking the competitive nature of some parent-child teams into account a different approach is needed in order to strengthen parent-child cooperation. One promising approach could be to let parents and children work on a mathematical problem that directs them to work together as a team in order to compete against other parent-child teams. Such a context could fuel the competitive nature of some parents and children, but at the same time strengthen their team building.

CONCLUSION AND OUTLOOK

The discovery learning situation of the paperboy's problem, presented here, offers parents and their children a possibility to investigate a mathematical problem on an equal footing. They have the opportunity to experience mathematics in an open, assessment-free setting together as a team and therewith could gain positive feelings of social relatedness, as well as mathematical competence. Sometimes such experiences between parents and their children were more intense, sometimes less.

Searching for parental attributes that may be linked to the form of parents working with their children in context of the math-experience-days, namely *parents as learners* or *parents as learning partners*, no direct relation to parental gender, age, educational qualification or the occupational field could be found. That does not mean that there is not any connection to those attributes, but that they are not explicitly related to the parent-child-cooperation, rather multifaceted in its nature or interwoven with other factors. Those factors could for example be parents' emotional dispositions towards mathematics or parental motivations to do mathematics. In some cases it already became obvious that parents' desire to investigate a mathematical problem on their own, their ambition to solve the problem for themselves is so dominant that the risk exists that they forget to cooperate with their children. Such factors influencing parents' ways to work with their children need to be investigated further in future research on the family math project.

Furthermore, it would be interesting to investigate more closely the impact of such a family math project on mathematical learning situations at home. As it seems, general mathematical learning situations at home, mostly in context of homework, are often accompanied by tension and stress. Several parents mention this issue in their answers being completely aware of the project's special status. In this context, the here presented results first and foremost indicate that an open-ended, problem-based discovery learning situation represents a fruitful context for children working together with their parents on a mathematical problem. In any case, the risk that parents overtake the role of the conveyor of knowledge is minimised by the nature of the presented learning environment. When, moreover, the task for parent-child cooperation is explicitly defined by activities like investigating the problem, comparing approaches and therewith generating ideas or strategies without pointing to an existing solution, the pressure to find an overall solution could be reduced even more. Hence, one promising approach, in order to foster parental involvement in their children's mathematical learning, could be to integrate such open-ended, problem-based discovery learning situations as special parent-child homework.

However, the nature of parent-child cooperation in those problem-solving contexts needs to be investigated further. It is clearly not enough to examine only

the course of one workshop, with one type of mathematical problem at hand, in order to get a holistic picture of parent-child cooperation and promoting or hindering factors. Consequently, it needs more and diverse family math workshops to investigate the conditions and dynamics of parent-child cooperation in open-ended, problem-based discovery learning environments. That will follow in the main survey.

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