The construction of low attainment in mathematics – why are primary school children selected for intervention programs? Results from a meta-analysis of case studies

Andrea Tiedke[1], Timo Dexel[2] and Ralf Benölken[3]

[1]University of Wuppertal, Germany; tiedke@uni-wuppertal.de

[2]University of Wuppertal, Germany; dexel@uni-wuppertal.de

[3]University of Wuppertal, Germany; benoelken@uni-wuppertal.de

This paper presents a study based on a meta-analysis of 43 case studies on primary school children participating in an extracurricular support program for low attaining children named MaKosi ('Mathematische Kompetenzen sichern'). Whereas this program particularly aims at identifying low attaining children and supporting their arithmetic skills, this paper investigates social factors that can be identified as shared and comprehensive to this group of children attending the support program. As part of the case studies, interviews were conducted with the children, their parents, and (mathematics) teachers in order to examine factors that may lead to or influence the assumed low attainment in mathematics. The results indicate an interplay between individual, social, and school-related factors, such as gender, self-concept, and the quality of classroom management.

Keywords: Low attaining children, case studies, social factors.

Introduction

Teachers, parents, and students typically assume that there are children who easily learn mathematics – and that there are those who do not. In psychological approaches learning difficulties are described as a consequence of dyscalculia or individual learning disorders that need to be 'cured' or, at least, need an intervention (Kuhn, 2015). Some mathematics educational researchers conceptualise dyscalculia or learning disorders as the result of inappropriate teaching and individual difficulties and, therefore, call for improvement of assessment and the quality of teaching. In addition, training or intervention programs, e.g., in universities have been implemented (in Germany at the universities of Münster, Wuppertal, Bielefeld, and many more) linking the identification and support of children, the training of student teachers, and research on learning difficulties. However, in this paper we follow Uwe Gellert's assumption that the characterisation of a group says more about the characteriser than about the characterised (Gellert, 2013). The phenomenon of low-attaining children in this understanding is not a natural or biological description of reality, but constructions that emerge in social and political contexts (ibid.). Low attainment can be problematised as a consequence of inequality. Consequently, socio-political perspectives on mathematics education focus on the contexts of the construction problems, e.g., in classroom interactions (Gellert, 2008; Heyd-Metzuyanim, 2013), as a matter of identity (Andersson et al., 2015) or (auto-)exclusion (Kollosche, 2019). A research desideratum addresses the question of how other agents such as teachers and parents come to the conclusion that there are learning difficulties that cannot be solved in the standard lessons. Complementing these studies, we ask, *which social factors can be identified regarding primary school children's attendance at an intervention program for low-attaining children.* We

would like to change the perspective by not examining what these learners need or what their (lacking) competences are, but why they are perceived as children who have difficulties and, therefore, are selected for intervention and in what way social factors affect this selection. To answer these questions, we draw on data of 43 case studies constructed by student teachers about children who are characterised as low attaining learners especially in arithmetic and attend an intervention program. First, we give a brief overview of the theoretical frameworks with respect to explanations for low attainment in mathematics and its construction in classroom interactions. After that, the study's methodology is outlined and justified against the theoretical frameworks. Finally, the results are presented and discussed.

Theoretical frameworks

As there are many definitions, classifications, and understandings of having problems in mathematics such as a (mathematical) learning disability, special needs in mathematics, mathematical learning difficulties, or dyscalculia (Scherer et al., 2016), in this paper we use the term low attainment with focus on arithmetic contexts. The term low attainment means that children do not show teacher's expectations of mathematical performance. It involves individual aspects of learning as well as social and cultural factors and, thus, can be seen as a complementing perspective on other (psychological) classifications (for an overview see Fritz et al., 2019; for a social-political perspective see Straehler-Pohl et al., 2017).

Low attainment in mathematics (LAM) between school, family, and the child

From a mathematics education viewpoint (unlike a psychological one) low attainment is conceptualised as a psycho-social interplay. Gaidoschik (2017) states that there are no actual evidence-based *causes* of LAM but numerous factors that make LAM more likely. These factors can be seen in the realms of school (lack of assessment, teaching mistakes, discontinuity, etc.), family (lack of support, anxiety, drill, etc.), or the child itself (self-concept, motivation, etc.). Benölken (2016) developed a model of LAM that connects inter- and intrapersonal 'risk factors'. Whereas family, peers, and the context of school are *inter*personal factors, there are further possible *intra*personal risk factors such as difficulties in concentrating, unfavourable mathematics-related self-concepts, or self-efficacy expectations, often as a result of multiple experiences of failure. Psychosocial approaches emphasise that such risk factors can exist not only within the individual, i.e., due to intrapersonal determinants or processes but also outside the individual, i.e., in his or her social environment: Family conditions are unfavourable, for example, due to an environment that is poor in stimulation and experience with regard to points of contact with mathematical content. Until now, there is a lack of empirical research on these risk factors and how they are connected to learner's development of LAM, but one can find hints in studies that research learner's identities or give reasons for (auto-)exclusion from mathematics education. Among others, Andersson et al. (2015) find out, that the identity of being a 'math hater' and corresponding disengagement in class can change over time. They state, that the contexts of task, situation, school organisation, and the socio-political context matter and that identity narratives change in relation to available contexts. Kollosche (2019) asks why learners reject mathematics and describes that auto-exclusion is motivated by the

organisation of mathematics education and closely linked to the subject of mathematics itself and, therefore, also represents a didactical problem.

In all these considerations of what the causes of LAM might be, in these approaches it is clear that there is an unsatisfactory performance in mathematics and that this must lead to support (Scherer et al., 2016). Other approaches, instead, question whether this shown performance corresponds to 'reality' at all or if it is a result of interactional (co-)constructions.

Construction of LAM in classroom interactions

Uwe Gellert and colleagues use Basil Bernstein's theoretical frameworks of pedagogic codes and their modalities of practice:

> When the mathematics teacher poses a problem, students need to respond in a manner that is seen as appropriate. They must be able to recognise that particular responses are expected, and they must be able to produce a desired response. (Gellert, 2008, p. 218)

These abilities are distributed unevenly with respect to the different socio-economic backgrounds of the children. Gellert shows, that achievement is not primarily based on childrens' mathematical abilities, but on their differential rule recognition responses (Gellert & Straehler-Pohl, 2011). Heyd-Metzuyanim (2013) shows in a case study that 'learning disability' is not an individual characteristic, but an interactional co-construction between teacher and learner, relying on the interplay of following rules and routines in the classroom. In this case, the learner responded to the rules of participation, but the mathematical content was mostly inappropriate so that she could not negotiate mathematical meaning. She had no choice but following routines without understanding. "The implications of these findings lie in highlighting the necessity of taking into account the social and affective, as well as the cognitive, aspects of learning difficulties in mathematics." (Heyd-Metzuyanim, 2013, p. 362).

These studies reconstruct the emergence of disparity while participating in classroom interactions. In contrast, Straehler-Pohl and Pais (2013) reconstruct mathematics educational failure as a consequence of very low academic expectations and, therefore, provoke learner's resistance. As non-participation is no legitimate option for children in everyday lessons, it leads to exclusion. Within these perspectives, LAM appear to be an interactional construction caused by practices and routines in school. In addition, however, this is criticised since the reasons for inequality can also lie outside the school context.

Researching the connection between social factors and the construction of LAM

Gutiérrez (2012) reminds us that "[…] learning is intricately connected to the contexts in which it occurs" (p. 18). She argues that there is a need to reclaim space for studies that focus on learning in context. Researchers must consider the complexity of the phenomenon. Pais criticises that "[a]ll the complexity of the social and political life of the student is wiped out of the research focus. The student is reduced to a biological entity, likely to be investigated in a clinical way." (Pais, 2012, p. 53). Though we do not agree with his overall assumptions, we emphasise taking social factors and contexts of learning into account. Our theoretical assumption is that performance in class is not the only reason to be assigned as low attaining but it is also a result of social constructions. Yet, the process of these constructions is not alone in the hands of teachers. We assume that there is an interplay between the

teacher's and the learner's views, between the quality of teaching, and the learner's situation. We seek to explore these complex interplays.

Methodology: Data collection and analysis

The present exploratory study is based on a meta-analysis of 43 case studies on primary school children who participated in a support program for low attaining children named *MaKosi* ('Mathematische Kompetenzen sichern' – 'ensure mathematical competences', translated from German). The long-term project *MaKosi* was conducted from 2014 to 2018 under the direction of Ralf Benölken at the University of Münster (Germany) in cooperation with a primary school (Benölken, 2016, 2017). It was organised as a 'learning-teaching-laboratory', i.e., a project seminar that links student teachers' theoretical and practical education by working with children. It mainly aims at developing student teacher's professional competences and supporting children characterised as low attaining in mathematics. In each semester the program took place in the afternoon at the primary school once a week over a period of four months. Each 90-minute-session was divided into three parts: at the beginning and at the end playful problem tasks respectively games were offered to support children's self-perception and joy of engaging in mathematics. The main part of the sessions was the 60-minute diagnostic and support unit in which one student teacher and one child worked together in one-to-one-interactions in established teams. During these sessions, the children worked on various tasks and the student teachers noted down the children's ways of thinking as well as aspects that stood out to them and that they considered particularly important and relevant in an observation log. Teachers and parents decided on the children's participation in the program: First, teachers were given information about the program and the theoretical framework. They elect children providing a written rationale. Then, parents were asked to fill in a consent form. The data we refer to in this study is drawn from the individual case studies that student teachers produced following the project *MaKosi* as part of bachelor's (in total 18) and master's (in total 25) theses on the children they worked with in the project over the full period. The case study approach provides a profound, multi-faceted appreciation of an issue, which is intended to paint a holistic and realistic picture of the social world (Lamnek, 2010). In case studies, triangulation of different methods, e.g., participant observation or (guided) interviews, is often used in order to capture all significant dimensions and facets of an issue and to be able to gain a more precise insight into how the diverse factors interact (ibid.). The case studies were primarily aimed at reconstructing the child's difficulties as well as risk factors that could promote these difficulties. In addition to the above-mentioned observation log on the children's way of thinking and their task completion, the students also used guided interviews with the children, their parents, and the mathematics teachers as data collection instruments. From these data, the students worked out how the child's development (including physical and academic development) progressed, how his LAM manifested itself, and what aspects they perceived as risk factors for LAM.

As stated in the introduction, we would like to change the perspective by not examining what these learners need or what their (lacking) competences are, but why they are perceived as learners who are low attaining. In other words, our aim is to reconstruct factors, especially social ones, that lead to these children being characterised as low attaining. Therefore, we conduct a meta-analysis that includes 43 case studies written as part of the project *MaKosi*. Using qualitative content analysis (Mayring, 2015), the risk factors described in the case studies were first coded using three categories

deductively derived from theory: *child*, *school*, *social environment* (Benölken, 2016; Gaidoschik, 2017). Subsequently, five subcategories were formed from the data in conjunction with the theoretical models of Benölken (2016) and Gaidoschik (2017) for each of the three superordinate categories: (1) The factors relating to the category *child* included the subcategories *work habits* (e.g., lack of independence, low perseverance or difficulties in concentrating), *developmental factors* (e.g., difficulties in motor skills, perception or language), *affective-motivational characteristics* (e.g., unfavourable mathematics-related self-concept or negative attitude towards the subject of mathematics), *general school-related insecurity* (e.g., discomfort, feelings of inferiority, or emotional reactions), and *relevance* (especially not recognising the importance of the subject for life). (2) For the category *social environment* the five subcategories *lack of stimulation* (e.g., an environment that is poor in stimulation and experiences for dealing with mathematical topics), *learning environment at home* (e.g., lack of support, difficult and unsettled family circumstances), *negative role models* (family members who have also been characterised as mathematically low-attaining or have unfavourable mathematics-related self-concepts), *lack of participation* (and of interest of parents in school-related matters), and *emotional stress* (e.g., due to divorce of parents or pressure) were formed. (3) The subcategories *discontinuity* (e.g., class repetition or frequent change of teachers), *relationship* (especially a negative relationship between child and mathematics teacher), *situation of the class* (e.g., restless classes with many learners or a negative atmosphere in the class), *classroom management* (quality of teaching, individual promotion) and *cooperation* (e.g., between teachers and parents or of different professions) are subsumed under the category *school*.

For each child, it could now be noted whether each factor was perceived as a relevant factor in the context of the case study. It was only asked whether the respective factor played a role and not how strongly it was perceived, i.e., no weightings were applied.

Results

Across the 43 case studies, the comparison of the categories showed that the subcategories belonging to the category *child* were most often perceived as risk factors for the children's LAM. The factors *work habits* (in total 36 times), *developmental factors* (32 times), and *affective-motivational characteristics* (28 times) were each described in a majority of the case studies. *Emotional stress* (20 times) and *lack of stimulation* (17 times) were the most frequently perceived factors in the category *social environment*, and in the category *school*, these were the two subcategories *classroom management* (26 times) and *discontinuity* (21 times). *Relevance* (7 times) and *cooperation* (4 times), on the other hand, were rarely assessed as relevant factors. When comparing the case studies with each other, the wide range of combinations of the fifteen subcategories perceived as risk factors is striking. For example, while only three relevant factors were identified for one child (all can be assigned to the category *child*), there are children for whom up to ten different factors were observed. Furthermore, the distribution of the perceived factors in the three areas of *child*, *school*, and *social environment* varies depending on the case study. In this respect, Figure 1 shows a possible typification of the individual cases in which, depending on the focus of the factors described, they were either primarily assigned to one of the three categories or located at the interface of two or all three categories.

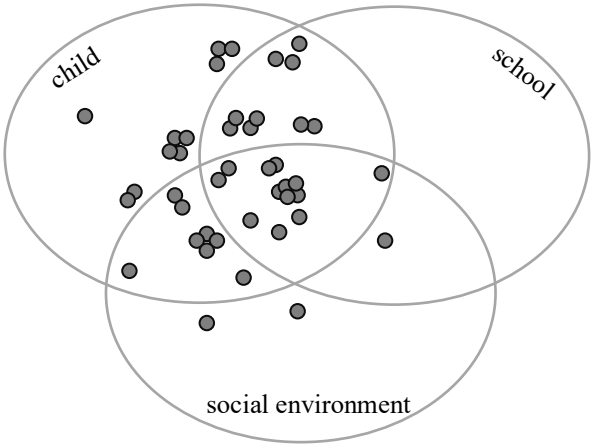

Figure 1: All cases

As can be seen in Figure 1, most of the individual cases are located in the centre or the upper-left area of the mapping. The focus of reconstructed factors for most of the children was, thus, on intrapersonal factors, i.e., category *child*, or at the interface of this category with one or both of the other categories. Furthermore, it can be seen that for none of the children in our case studies a clear focus on *school* factors was described. Nevertheless, as shown above, *classroom management* was one of the most frequently mentioned factors. The meta-analysis also showed that a large proportion of the individual cases considered (a total of 30 out of 43, i.e., almost ¾) were female. If we now look at the focal points of the factors described in the case studies for girls and boys separately, as shown in Figure 2, we can see that the individual case studies of boys are quite scattered.

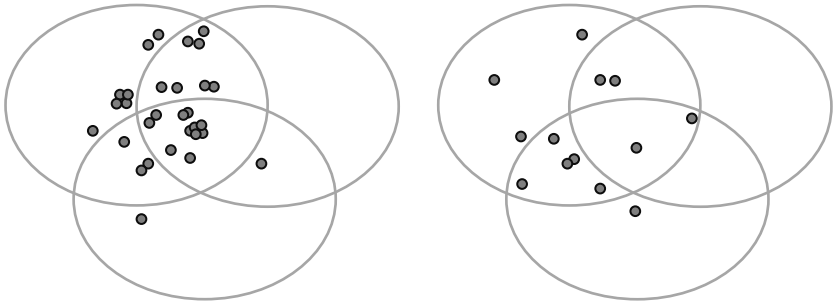

Figure 2: Cases split by gender (on the left: girls; on the right: boys)

Rather often, however, they include types that combine factors that can be assigned to the area of the *social environment*, but have fewer *school*-related factors. Many girls, on the other hand, show a combination of factors belonging to the categories *child* and *school*, whereby an accumulation of affective-motivational characteristics is particularly noticeable. Thus, 23 girls were perceived to have an unfavourable mathematics-related self-concept. In summary, it can be stated that a combination of different factors from the three categories seems to be prevalent in many children, whereby in the case studies the students mainly reconstructed factors regarding the category *child*. In the other two categories, individual factors were dominant, for example classroom management or emotional stress.

Discussion

The results confirm that there is a complex interplay between perceptions of LAM. Especially girls with a negative self-concept and unfavourable motivational factors were selected. Two points seem

important to us: first, inequality with respect to gender is a well-known and unsolved problem in Germany. Cultural factors seem to play a role because these differences do not exist to this extend in other countries. Second, the question of individual factors corresponds to the assumption of Heyd-Metzuyanim (2013, p. 363): "The problem lies in the permanence of the disability title and the apparent disregard for the social and affective processes that may be (at least partially) responsible for its development in the first place." The girls are labelled as having problems and similarly see themselves, which, again, has consequences for their performance. In addition, the children's education is characterised by discontinuities. Many of them repeated or were repeating a school year. However, Gellert's (2008, 2013) results show precisely that being perceived as high- or low-performing is related to following rules of discourse. If children do not have access to these rules, repeating a school year does not change that. Benölken (2016) and Gaidoschik (2017) focus on risk factors that lead to LAM. We also found a striking relation between classroom management, emotional stress, and school-related insecurity in general. In addition to Gaidoschik's and Benölken's views we argue that these social factors may indeed have an impact, but especially they make a categorisation of children more likely. In our case studies we found a low attaining girl that scored high achievements in other mathematical assessments conducted by student teachers. All in all, we identify several aspects that seem to influence teachers' and parents' decisions for selecting children – at least gender and self-concept play a role – that appear in mathematics lessons as performance or attainment. These social factors seem to be 'hidden' under the construct of low attainment. At the same time, we recognise a low quality of mathematics lessons and teaching, discontinuities in didactics, and an unfavourable learning atmosphere. None of this will change by learners attaining intervention programs because the lessons and school contexts themselves are problematic. When it comes to supporting learners, it seems adequate to focus not only on mathematical, but broader facets like motivation and self-concept (which is indeed intended in *MaKosi*). Surprisingly, we could not find any relation to socio-economic factors. This leads to the limitations of our study. As the program was conducted at *one* school in a relatively privileged region, there were hardly any economically disadvantaged children. We see our study as work in progress; different children with different backgrounds and different schools need to be included.

References

Andersson, A., Valero, P., & Meaney, T. (2015). "I am [not always] a maths hater": Shifting students' identity narratives in context. *Educational Studies in Mathematics*, *90*(2), 143–161.

Benölken, R. (2016). "MaKosi" – Ein Förder-, Lehr- und Forschungsprojekt im Themenkomplex "Rechenprobleme". In R. Benölken & F. Käpnick (Eds.), *Individuelles Fördern im Kontext von Inklusion* (pp. 51–63). WTM.

Benölken, R. (2017). Developing student teachers' professional knowledge of low attainments' support by "learning-teaching-laboratories". In T. Dooley & G. Gueudet (Eds.), *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education* (CERME10, pp. 3264–3271). Dublin, Ireland: DCU Institute of Education and ERME.

Fritz, A., Haase, V. G., & Räsänen, P. (Eds.). (2019). *International handbook of mathematical learning difficulties: From the laboratory to the classroom*. Springer International Publishing.

Gaidoschik, M. (2017). *Rechenschwäche – Dyskalkulie: Eine unterrichtspraktische Einführung für LehrerInnen und Eltern* (10th ed.). Persen.

Gellert, U. (2008). Validity and relevance: Comparing and combining two sociological perspectives on mathematics classroom practice. *ZDM*, *40*(2), 215–224.

Gellert, U. (2013). Heterogen oder hierarchisch? Zur Konstruktion von Leistung im Unterricht. In J. Budde (Ed.), *Unscharfe Einsätze: (Re-)Produktion von Heterogenität im schulischen Feld* (pp. 211–228). Springer Fachmedien.

Gellert, U. & Straehler-Pohl, H. (2011). Differential access to vertical discourse: Managing diversity in a secondary mathematics classroom. In M. Pytlak, T. Rowland, & E. Swoboda (Eds.), *Proceedings of the Seventh Congress of the European Society for Research in Mathematics Education* (CERME7, pp. 1440–1449). Rzeszów, Poland: University of Rzeszów and ERME.

Gutiérrez, R. (2012). Context matters: How should we conceptualize equity in mathematics education? In B. Herbel-Eisenmann, J. Choppin, D. Wagner, & D. Pimm (Eds.), *Equity in discourse for mathematics education: Theories, practices, and policies* (pp. 17–33). Springer.

Heyd-Metzuyanim, E. (2013). The co-construction of learning difficulties in mathematics – teacher-student interactions and their role in the development of a disabled mathematical identity. *Educational Studies in Mathematics*, *83*(3), 341–368.

Kollosche, D. (2019). Reasons for auto-exclusion: Why students reject mathematics. In D. Kollosche, R. Marcone, M. Knigge, M. G. Penteado, & O. Skovsmose (Eds.), *Inclusive mathematics education: State-of-the-art research from Brazil and Germany* (pp. 449–465). Springer International Publishing.

Kuhn, J.-T. (2015). Developmental dyscalculia: Neurobiological, cognitive, and developmental perspectives. *Zeitschrift für Psychologie*, *223*(2), 69–82.

Lamnek, S. (2010). *Qualitative Sozialforschung* (5th ed.). Beltz.

Mayring, P. (2015). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (12th ed.). Beltz.

Pais, A. (2012). A critical approach to equity. In O. Skovsmose & B. Greer (Eds.), *Opening the cage: Critique and politics of mathematics education* (pp. 49–91). Sense Publishers.

Scherer, P., Beswick, K., DeBlois, L., Healy, L., & Opitz, E. M. (2016). Assistance of students with mathematical learning difficulties: How can research support practice? *ZDM*, *48*(5), 633–649.

Straehler-Pohl, H., Bohlmann, N., & Pais, A. (Eds.). (2017). *The disorder of mathematics education: Challenging the sociopolitical dimensions of research*. Springer.

Straehler-Pohl, H. & Pais, A. (2013). To participate or not to participate? That is not the question! In B. Ubuz, C. Haser, & M. A. Mariotti (Eds.), *Proceedings of the Eighth Congress of the European Society for Research in Mathematics Education* (CERME8, pp. 1794–1803). Ankara, Turkey: Middle East Technical University and ERME.