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Teachers' view of twice-exceptional students – outline of the challenges in recognizing mathematical giftedness and supporting needs of hearing impairment

Dirk Weber¹, Sarah Beumann¹ and Ralf Benölken¹

¹University of Wuppertal, Germany; dweber@uni-wuppertal.de

Mathematically gifted children may have special educational needs due to various disabilities. The term “twice-exceptional” has been established for this alleged minority of learners. Characteristics of this phenomenon can often cause potentials and learning disabilities to mask each other, or learning barriers to be concentrated at an intrapersonal level. It can be assumed that teachers' knowledge and understanding of twice exceptionality is a prerequisite for the identification of strengths and weaknesses in the learning process in order to be able to adequately support the children's individual potential. However, simultaneous identification of mathematical giftedness and special educational needs is challenging due to its intersectional complexity. Based on a case study of a hearing-impaired student, this paper outlines one teacher's view of the challenges of identifying twice-exceptional learners.

Keywords: Twice-exceptional, mathematical giftedness, teachers' view, identification, hearing impairment.

Introduction and rationale

In the context of mathematics education, there are rather few studies on twice-exceptional (“2e”) students (e.g., Brandl & Nordheimer, 2016). This refers to children who have two specific dispositions that can intersectionally determine a highly specific individual needs profile. Existing research mainly focuses on case studies that aim at describing such intersectional considerations and their characteristics (e.g., Montgomery, 2003). For example, typical phenomena such as underachievement (Sparfeldt et al., 2006) can complicate the identification of high mathematical potential in 2e students (Nolte, 2018). Therefore, knowledge about different facets of diversity (e.g., mathematical giftedness or special needs) as well as competencies for their identification and methods of their respective specific and intersectional support (Benölken, 2020) seem particularly relevant to improve the identification and support of 2e students. The aim of this paper is to explore the challenges, both in terms of teachers' views on the 2e topic and issues of identification as well as support, through a case study. First, some relevant theoretical background is outlined, followed by a report of the case study of a hearing-impaired learner. Finally, the overall impressions will be comprehensively discussed.

Impressions from the literature

Research on 2e students is rarely domain-specific (Dimitriadis et al., 2021). It tends to focus on larger groups such as attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD) or specific learning disabilities (e.g., Foley-Nicpon et al., 2013) rather than sensory impairments (Hughes, 2021). Even case reports are rare, especially in mathematics education. An example is given by Brandl and Nordheimer (2016), who refer to the communicative characteristics and contradictory

results regarding the development of arithmetic skills of hearing-impaired 2e students. Indications have been found that existing instruments and diagnosis procedures for the identification of mathematical giftedness are hardly suitable for the identification of 2e learners due to their individual characteristics (Kalbfleisch & Iguchi, 2008). One reason for the lack of conceptualizations for the identification of 2e students may be seen in the prevalence of this group of learners, which is assumed to be low (Hughes, 2021). In addition, individual expressions of giftedness in 2e learners are concretely influenced by the nature and specificity of their learning barrier (VanTassel-Baska & Baska, 2004) – at least some research suggests that teachers typically tend to focus on, for example, weakness or learning barriers (Chiang & Lin, 2007; Tannenbaum & Baldwin, 1983). Such possible teacher biases obviously influence the design of the learning opportunities with the result, that they do not meet accepted criteria for material to support mathematically gifted children (e.g., Hughes, 2021). In this paper we address a holistic view of mathematical giftedness that reflects the research consensus (Fuchs & Käpnick, 2009). Of course, the professional competencies of teachers are important with regard to the identification and support of 2e students (Webb et al., 2016). The country-specific frameworks play a special role, as the support of children with disabilities is usually provided by special educators, who mostly do not have specific competences with regard to the identification and support of high mathematical potentials (e.g., Dimitriadis et al., 2021). Based on the impressions from the research literature, it could be concluded that more in-depth research is needed from a specific perspective of mathematics education, e.g., to gain deeper insights into the possibilities of identifying and supporting 2e students with high mathematical potential.

The study

The study presents the case example of Ms. Schroeder (39 years old, teacher of mathematics and music) and aims to outline her understanding of the diversity of 2e. The research question is, what views can be found on both the identification and support of mathematical giftedness as well as the support of hearing impairment. The study was carried out in a comprehensive school near Dusseldorf, Germany, during the practical semester of the final phase of the academic studies at university: a future teacher, a master's student, regularly attended Ms. Schroeder's mathematics class for four months. The learning group is an inclusive learning group of 28 children, participated by Niklas, a thirteen-year-old hearing-impaired boy. A case study of Niklas was conducted in terms of a holistic diagnosis of mathematical giftedness, including an open interview with his teacher, Ms. Schroeder. In this respect, the case study includes a semi-standardized introductory test with indicator tasks (Sjuts, 2017), open classroom observations over several weeks, many clinical interviews while working on problem tasks with the boy, and the interview with Ms. Schroeder that is illuminated as a case excerpt that is linked to, but detached from, the Niklas case study in this paper.

Impressions from the case study

The role of the master's student was to facilitate and engage the hearing-impaired learner, Niklas, in one-to-one problem solving. During the individual support it was noticed that Niklas had good ideas and solved mathematical problems very well. Therefore, a semi-standardized introductory test was carried out to explore his potential for giftedness. Niklas completed a modified test (with less auditory content) with a very good result (26 out of 32 points). In particular, structuring on the pattern level

(90% of all points; Sjuts, 2017) is very pronounced with Niklas. On the basis of all impressions (from the individual support and the test), Niklas can be identified as mathematically gifted.

Open-ended classroom observations

During the mathematics lessons, it was evident that Ms. Schroeder uses very clear and distinct language as well as she tries to make eye contact with Niklas as often as possible. Ms. Schroeder never speaks to the children facing the blackboard and writes all important (mathematical) terms on the blackboard. In addition, a memo book is kept in class, which the children can access at any time. Overall, the teacher responds well to Niklas and appears to be knowledgeable about the special communication needs of hearing-impaired children. However, from the observations it became clear that the teacher does not use open task formats and mostly teaches in a frontal way. Cooperative forms of learning are very rarely used and the work is mostly done according to a fixed plan. On the basis of these observations, it was decided that Niklas should be confronted with open-ended problems in individual support.

The teachers' view

In an open interview as part of a complex case study, the mathematics teacher of Niklas, Ms. Schroeder (Ms. S.) explained why she used few or no open-ended tasks (translated from German):

Ms. S.: I often feel uncomfortable using such tasks. Even with normal children you never know what the results will be and whether their method is appropriate for the lesson topic. With Niklas in the class it is even more difficult [...] I am simply afraid of not doing justice to him and his disability. I have a very fixed procedure so that Niklas follows the lesson as much as possible [...]. I don't want to lose him.

Ms. Schroeder's view has implications for her classroom practice (Koshy, 2001). She indicates her discomfort in the context of inclusive teaching and therefore tries to focus the lesson clearly on the teacher's side and primarily on the boy's weakness or disability. Her expertise in supporting hearing impairment gives her the confidence to achieve the learning outcomes. When Ms. Schroeder was confronted with the results of the giftedness test and the individual support, she replied (translated from German):

Ms. S.: I was not aware that Niklas had special mathematical potential [...] but if I am honest, I am not familiar with mathematical potential and talents either. And I didn't realise that children with disabilities can also be mathematically gifted, because they have a problem [...] and giftedness and problems don't go together for me [...] after all, hearing-impaired children don't have a large vocabulary or many ways of communicating and are therefore not able to solve complex tasks. I have always thought that a disability has limitations and is therefore associated with reduced performance.

Here the focus in dealing with Niklas and his disability is evident. The teacher admits her lack of knowledge regarding mathematical giftedness, so there are also discrepancies regarding this focus of support as well as his competencies. Niklas is mainly taught with a focus on spoken language and he does not show any serious learning disabilities in the area of speech and articulation due to his early provision with hearing aids. The teacher does not seem to be informed about this meaning, but seems to generalize the characteristics of the special focus on hearing impairment, which can have very

diverse characteristics. The teacher was then asked about her knowledgeable of the boy's competencies (translated from German):

Ms. S.: Niklas has a diagnosed disability and was a special needs student in primary school. His disability clearly has an impact on his performance. I have always considered performance of Niklas to be in the lower range and have adapted my teaching accordingly. The level of achievement in the class is not high, so I have never needed open-ended tasks, because the arithmetic was already difficult.

Ms. Schroeder generalizes the boy's disability and relates his weakness to his performance difficulties. In doing so, she has never questioned what Niklas is actually capable of in terms of performance (translated from German):

Interviewer: Do you know when Niklas was fitted with a hearing aid or how he learned to speak?

Ms. S.: No, I was never interested in that. All I know is that Niklas went to a special school and I concluded that his abilities must be limited. I also don't know what effect this might have in terms of time. Niklas has a special focus, so he can't hear very well and therefore needs help. He gets this help from me by structuring the lessons, writing everything on the board and keeping a memo book. That's how I learned to support during my training.

In this interview it seems that the potential of Niklas is masked by his disability. Apparently, his teacher has a deficient understanding of disability and its manifestations. She generalizes the boy's need for support without addressing his abilities and limitations. Obviously, Niklas is not being taught in a potential-oriented way, which seems to be a consequence of the teacher's level of knowledge. Ms. Schroeder admits that she is following exactly the German recommendations for teaching hearing-impaired children by referring to a relevant manual on the characteristics of this group of learners.

Conclusions: challenges in identifying and supporting 2e

The reported case example illustrates the challenges teachers face in considering and identifying diverse learning needs and specific facets of diversity (e.g., Hughes, 2021). Niklas can be described as twice-exceptional (e.g., Nolte, 2018), as he is mathematically gifted with strengths in for example pattern-level structuring, but also has weaknesses due to a hearing impairment that directly or indirectly affect his ability to reach his full potential. So how can Ms. Schroeder's specific problems in identifying the boy's mathematical potential be explained?

The challenges in identifying 2e students can be related firstly to the specificity of this facet of diversity. First and foremost, 2e students are gifted, but their individual expression of giftedness is concretely influenced by the nature and specificity of their learning barrier (VanTassel-Baska & Baska, 2004). Thus, a joint consideration of strengths and weaknesses seems worthwhile because of this interaction (Hughes, 2021). As a result, paradoxical characteristics of 2e students, e.g., independence and motivation in their area of strength versus special support needs or avoidance behaviour in their area of weakness (e.g., Brandl & Nordheimer, 2016), are formative for this facet of diversity (Hughes, 2021). Individual characteristics associated with this not seldom cause potential of giftedness and learning needs to mask each other (e.g., Nolte, 2018) and teachers, like Ms. Schroeder, often focus on the learning barrier in practice (Tannenbaum & Baldwin, 1983). Furthermore, while 2e students are able to comprehend complex content and concepts, they struggle to learn basic skills (e.g., Brandl & Nordheimer, 2016; Hughes, 2021); therefore, from Ms.

Schroeder's perspective, a small-step approach to instruction is initially obvious for support. Because of the hierarchy of content, her mathematics lessons are rarely structured to introduce whole mathematical concepts. However, Steinbring (1998), for example, discusses the misunderstanding of mathematics education that its reference science suggests a step-by-step learning from the simple to the complex to the abstract.

Dimitriadis et al. (2021) point out that teachers' knowledge of 2e tends to refer to specific combinations such as gifted and ADHD or gifted and autism rather than to the phenomenon in general or, in this specific case, to sensory impairments (Hughes, 2021). Regardless of the learning barrier, however, it can be assumed that knowledge and understanding of the phenomenon 2e and its individual characteristics are prerequisite for identification in terms of potential-oriented support for both exceptions and counteracts misdiagnosis or failure to diagnose (Webb et al., 2016), which can lead to the compression of learning barriers at an intrapersonal level (e.g., Nolte, 2018). Based on Ms. Schroeder's statements, it can be assumed that she does not expect a student to have both disability and giftedness.

Due to the often-expected low prevalence of 2e students (e.g., Hughes, 2021), teachers like Ms. Schroeder pay little attention to their intended identification, even though up to 2% of all children may be affected by the 2e phenomenon due to the multifaceted nature of possible learning barriers (Hughes, 2021). The complex dynamics and individual characteristics of giftedness require the professional design of stimulating learning opportunities in which giftedness can be revealed (e.g., Renzulli, 2012). Accordingly, it can be assumed that the design of learning opportunities has an impact on the identification of learning barriers and of domain-specific as well as personality-specific characteristics of giftedness (e.g., Fuchs & Käpnick, 2009). This is also reflected in Ms. Schroeder's statements and her view or expectation and ultimately, above all, in the closed instructional design.

Learning opportunities in the context of mathematical giftedness are usually designed to be open (Fuchs & Käpnick, 2009), whereas learning opportunities in the context of special education needs often are designed more closed (Graham & Harris, 2003). From a mathematics education perspective Ms. Schroeder's instruction, as outlined, cannot be considered an open and gifted learning opportunity. Competencies for designing appropriate open-ended and substantial learning opportunities can be accomplished within the context of multi-professional teamwork and specialists in both exceptions, i.e., the strengths and weaknesses of 2e students (e.g., Foley-Nicpon et al., 2013). Unsurprisingly, multi-professional teamwork also can be a positive factor in the recognition of 2e students (Nielsen & Higgins, 2005). However, Ms. Schroeder teaches alone without the support of a specialist. Furthermore, at the level of teachers, country-specific framework of the school system as well as the training of teachers should be emphasized (Hughes, 2021), which have an impact on the consideration of 2e students, e.g., with regard to the identification of their potential as a result of external differentiation and prioritization of their learning barriers, which can lead to disadvantages. In Germany, the support of students having special educational needs, such as hearing impairment, is usually considered by special educators. Whilst this specialization may be appropriate for addressing barriers in learning, it can lead to a focus on weaknesses in relation to the paradoxical characteristics of 2e students (Tannenbaum & Baldwin, 1983). Teachers without appropriate

knowledge, as suggested, tend to focus rather on the learning barrier than on the mathematical potential of 2e students (Chiang & Lin, 2007).

With regard to a professionalization of teachers to this area, the rather thin study base is not without contradictions. On the one hand, special education teachers with additional qualifications in the context of giftedness are more successful in considering 2e students than teachers who have experience of working with gifted children and have received additional training in the context of special education. On the other hand, in the U.S, gifted education specialists, as opposed to special education teachers, are in principle more knowledgeable about 2e (Foley-Nicpon et al., 2013). Dimitriadis and colleagues (2021) have not been able to demonstrate this relationship between additional training and increased teacher knowledge of 2e for the UK. They explicitly refer to the different framework and specific teacher training of the two countries.

Assuming that Ms. Schroeder has competencies in the area of 2e, the question arises how she could identify individual mathematical potentials with the help of diagnostics. It may be successful if learning barriers can be filtered out in this process (VanTassel-Baska & Baska, 2004). However, the problems of identifying mathematically gifted children can certainly be discussed (Brandl, 2014; Singer et al., 2016). Intelligence tests, which diagnostics and total score are primarily based on student's performance on subscales, are not very suitable as exclusive instruments for identifying the potential of this facet of diversity, especially since they do not necessarily meet frameworks of mathematical giftedness (Brandl & Nordheimer, 2016; Kalbfleisch & Iguchi, 2008). In the context of mathematical giftedness, there can be no question of ideal testing methods across theories (Renzulli, 2012), although reference can be made to established approaches, such as indicator task tests (Käpnick, 1998), which the master's student also used and which could identify the giftedness characteristics of Niklas to a certain extent. Due to the text-heavy and visual conditions, the semi-standardized test had to be adapted. In this regard, Brandl and Nordheimer emphasize that

the type of communication and task setting in any testing, observation, or selection processes, especially in relation to factual tasks, therefore plays a crucial role in identifying mathematical giftedness potentials of hearing-impaired children. (2016, p. 233)

Accordingly, the identification of mathematical giftedness in children with hearing impairment is specifically complicated by language barriers, which is why their diagnostics should be interdisciplinary. Nevertheless, the combination of qualitative observations and quantitative tests does not necessarily lead to clear results for 2e students with hearing impairment (Brandl & Nordheimer, 2016).

Summary and outlook

The question was, what challenges in recognizing mathematical giftedness and supporting needs of students with hearing impairment can be reflected based on a teacher's view. With the help of the research literature, mainly non-domain-specific challenges could be illustrated. Teachers need professional competencies and knowledge in the context of 2e that equally focus on both weaknesses, such as specific barriers in learning, and strengths, such as mathematical giftedness, in order to adequately implement the identification of 2e students (e.g., Dimitriadis et al., 2021; Foley-Nicpon et al., 2013). However, it should be noted that neither the specifics of 2e students have been

reconstructed nor are there appropriate guidelines for identifying their needs in the context of mathematical giftedness, and research on this group opens a desideratum in the context of giftedness equity. Ms. Schroeder's provides a practical insight into a teacher's view and (mis)understanding of a 2e student, representative of a variant facet of diversity. The case example illustrated the challenge of identifying 2e students that has not been elaborated much in the literature specific to the field of mathematics education. In order to support mathematics teachers in the unfolding of professional action competencies, research for the development of a viable concept should focus on the identification and support of 2e learners and possible catalyst effects that impact giftedness development as well as the empirically based identification of essential needs and barriers in the learning process of this group of students.

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