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WHO EDUCATES MATHEMATICALLY GIFTED STUDENTS: PERSPECTIVES OF PROSPECTIVE MATHEMATICS TEACHERS

Abstract: This qualitative research aimed to examine prospective mathematics teachers' perspectives about the teachers of mathematically gifted students. The participants of this study were 17 prospective secondary mathematics teachers and 23 prospective primary mathematics teachers, 40 prospective mathematics teachers in total, who have received their education at a state university in Turkey. In order to collect the data, (i) written explanations of all prospective mathematics teachers, (ii) one whole-class discussion with primary mathematics teachers, and (iii) three focus group interviews with both primary and secondary mathematics teachers were used. Content analysis was used while analyzing the data. The findings indicated that prospective mathematics teachers mostly associated teachers of mathematically gifted students with teachers' personality traits. They also took into account teachers' content knowledge and pedagogical knowledge. They highlighted the importance of mathematical content knowledge while educating mathematically gifted students. The prospective mathematics teachers also emphasized having knowledge of giftedness and gifted education.

Keywords: mathematically gifted students; prospective mathematics teachers; teacher education; gifted education; pedagogical knowledge.

1. Introduction

One of the critical issues in the gifted literature is the teachers who will educate the gifted students. Since teachers play a crucial role in meeting gifted students' needs and nurturing their abilities in both homogenous and heterogeneous educational settings, all teachers should be able to recognize these students (Fraser-Seeto, 2013; Fraser-Seeto, Howard, & Woodcock, 2015). Literature provides insight into the various characteristics of gifted students' teachers, such as being creative, spontaneous, and having positive attitudes in classrooms, all attributable to effective teachers (Chan, 2001, 2011; Davis, Rimm, & Siegle, 2014). Feldhusen (1997) noticed more specific characteristics and competencies of gifted students' teachers like being flexible, respectful, and intelligent; having content knowledge and several interests; teaching problem solving and thinking skills; encouraging independent work, and using adequate motivational techniques. Yet, he also highlighted the distinction among the requirements for teaching specialized areas, all attributable to effective teachers including, art, music science, and mathematics.

New mathematics teachers are responsible for realizing students' talents and adjusting the appropriate tasks for the students in their classrooms. This role is also crucial for the gifted students who get their education mostly in heterogeneous classrooms. Constructing an environment that considers gifted students' cognitive and affective needs is also one of the critical roles of teachers (Applebaum, Freiman, & Leikin, 2011). In mixed classes, teachers mainly prefer to choose tasks and activities for the average level of the classrooms (Leikin, 2011b; Levenson, Tirosh, & Tsamir, 2009).

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Consequently, mathematically gifted students often cannot realize their potential, get bored, or are labelled unsuccessful (Applebaum et al., 2011; Fraser-Seeto, 2013; Levenson & Gal, 2013). The education of mathematically gifted students includes modifying teaching methods (Karp & Busev, 2015). Since working with gifted students requires some specific aspects, it can be challenging for the teachers (Karp, 2010). When teaching mathematically gifted students, the literature points out the need for well-trained teachers with content-specific knowledge (Hansen & Feldhusen, 1994; Karp, 2010). Most teachers are unaware of their students' mathematics abilities and cannot meet their needs because they lack knowledge or experience (Diezmann & Watters, 2002). Teachers are mostly expected to identify and nurture their gifted students in mixed classrooms (Fraser-Seeto et al., 2015). Research shows that a common misconception is that gifted students are likely to achieve independence, which is not true (Moon, 2009). Literature supports that education and educators influence these students' improvement and achievement (Fraser-Seeto et al., 2015; Mingus & Grassl, 1999). It is also crucial for gifted students to have teachers who nurture their students' potential and recognize their needs. If teachers had limited knowledge and ideas about the nature and characteristics of gifted students, they could hinder their giftedness and have difficulty in classroom management and choosing appropriate tasks (Applebaum et al., 2011; Freiman & Sriraman, 2007). Educational systems mostly give the responsibility to classroom teachers for differentiating the curriculum and nurturing gifted students (Diezmann & Watters, 2000). In this regard, teachers' knowledge and beliefs about how to educate mathematically gifted students are crucial for these students to realize their potential (Even, Karsenty, & Friedlander, 2009). With the scope of this study, thinking and being aware of the issues related to mathematical giftedness, such as the education of these students, could contribute to prospective mathematics teachers' future professional careers. This study may be considered a beginning step in creating prospective teachers' awareness of the issues of educating mathematically gifted students. The study also has the potential to shed light on the literature about how prospective teachers consider these issues in a domain-specific manner, namely in mathematics. Therefore, the study's research question is "What kinds of perspectives do prospective mathematics teachers have on the teachers of mathematically gifted students?"

Teachers of mathematically gifted students

In this study, students labelled as "mathematically gifted students" have potential in mathematics and exhibit crucial mathematical abilities in the society. Teachers have a critical role in nurturing students' talents in the classrooms. In mathematics classrooms, teachers should be able to teach mathematics in depth and effectively to construct a challenging environment for all of the children, recognize students' potential, and arrange the context according to the needs of the gifted students (Dimitriadis, 2016; Koshy, 2001; Sheffield, 1999). Mathematics teachers often have difficulties designing instruction, especially when there is a wide range of abilities in their classrooms. Differentiation can be an alternative way to provide challenges according to all students' needs (Reed, 2004). A teacher can differentiate some components of a lesson, such as content, process, and product in order to meet all students' needs in heterogeneous classrooms (Tomlinson, 1999). Mathematics teachers should also focus on connecting with other scientific disciplines while attempting to modify the curriculum (Stepanek, 1999). Besides, personal and social characteristics of teachers can also have a considerable impact on the education of gifted students (Chan, 2001; 2011; Davis et al., 2014; Leikin, 2011a).

Since working with gifted students requires some specific aspects, it can be challenging for the teachers (Karp, 2010). There is a discussion about whether the teacher of gifted students should also be gifted in the literature (Davis et al., 2014; Leikin, 2011b). However, it is clear from the literature that "in order to be a successful mediator for gifted students, one would undoubtedly have to be intelligent enough to be able to understand their way of thinking, knowledgeable enough to be able to challenge them and, last but not least, emotionally intelligent" (Rosemarin, 2014, p. 263). The standards for preparing teachers of gifted students can provide insights into effective and desirable

teachers of this population. These standards are foundations, development, and characteristics of learners, individual learning differences, instructional strategies, learning environments and social interactions, language and communication, instructional planning, assessment, professional and ethical practice, and collaboration (VanTassel-Baska & Johnsen, 2007). It is also stated that the teachers of gifted students should have personality traits such as empathy, willingness, and maturity to work with other educators (Davis et al., 2014). Maker (1975) declared that being open to change and having good relations with gifted students are two critical characteristics of these teachers. Besides, they “must be sensitive to the special needs of students, and be more attentive, flexible, and reflective” (Leikin, 2010, p.167). Leikin (2011a, p.86) also states that an experienced mathematics teacher working for years with gifted students in Russia “addresses in his teaching all the components of students’ mathematical potential (intellectual, affective, and social) and in this way provides students with multiple opportunities for the realization of their potential.” Requirements for being a gifted student teacher may differ according to domain-specific areas and subgroups of the gifted population (Chan, 2001; VanTassel-Baska & Johnsen, 2007). For the mathematics area, Karp (2010) asserted that having subject matter knowledge, loving mathematics, promoting learning, and viewing mathematics teaching as a creative art are the requirements of effective teachers of mathematically gifted students. Leikin (2011a) similarly emphasized that mathematically gifted students’ teachers should (i) have strong subject matter knowledge in mathematics, (ii) have enthusiasm towards mathematics and a sense of humour for creating positive atmosphere and joyful learning, (ii) be able to differentiate the abilities of students individually and challenge, and (iv) be supportive and respectful for the gifted students. In gifted classrooms, teachers also “provide less scaffolding and more autonomy to their students” (Leikin, 2010, p.167). Besides, knowledge of giftedness and counselling gifted students can also be seen as qualifications of the teacher of a gifted student (Davis et al., 2014). To conclude, the teachers of mathematically gifted students should have strong mathematical knowledge, pedagogical skills, and personal-social qualities (Karsenty, 2014). Literature has also shown that working with mathematically gifted students improves both subject matter and pedagogical knowledge, and their personal growth (Karp, 2010; Karsenty, 2014). In this sense, reflective thinking on how to train gifted students could trigger prospective mathematics teachers’ awareness about mathematically gifted students who will likely be in their classes.

2. Methodology

The participants of the study were 40 prospective mathematics teachers who took the “Teaching Methods on Mathematics Education” courses in a four-year mathematics teacher education program at a state university in Turkey. There were 23 prospective primary mathematics teachers and 17 prospective secondary mathematics teachers in these courses. Prospective primary teachers took this course in the third year of the primary mathematics teacher program, and prospective secondary teachers took this course in the fourth year of the secondary mathematics teacher program. During their education program, the prospective teachers did not take any courses related to giftedness. This allows them to contribute their naive thoughts to the research question.

Participants’ written explanations, whole-class discussions, and focus group interviews were used while gathering the data. Some open-ended questions were first asked to the prospective teachers. One of the questions was, “What could be the characteristics of the teachers of the mathematically gifted students for you?”. Taking their written explanations took 45 minutes for these questions. After that, an audio-recorded classroom discussion was organized with only 23 prospective primary mathematics teachers. This classroom discussion lasted approximately 35 minutes. Lastly, three video-recorded focus group interviews were conducted with prospective teachers who voluntarily agreed to participate in the interviews. The first group interview was made with seven prospective secondary mathematics teachers. The second and third interviews were conducted with 11 prospective primary mathematics teachers divided into groups of 5 and 6 participants, respectively. Each of these interviews took approximately 100 minutes. The researcher used the participants’

written explanations as prompts to make them think in detail about the research subject during the focus group interviews. Content analysis was used while analysing the row data (Patton, 2002). Firstly, the patterns related to teachers of mathematically gifted students were clarified. Then, literature served as guidance while determining these patterns as categories in line with the aim of the study. For instance, when the statements of the participants, such as “It is nice for children to realize that research is a good thing, that not everyone knows everything, that they can reach knowledge by searching, and the teacher may not know.” were observed in the data sources, they were coded in the “mathematics teachers’ personality traits” category. In the findings, PT-X represents a prospective teacher who participated in this study.

3. Findings

As stated, teachers’ actions and characteristics are crucial in nurturing gifted students’ mathematical talents. The prospective mathematics teachers’ thoughts on the mathematics teachers of the mathematically gifted students were coded into three categories, stated in Table 1. One of these categories is related to “personality traits” of the teachers. The other two categories emerged from the data as mathematics teachers’ knowledge about “mathematics” and “giftedness and gifted students”.

Table 1. Categories and sub-categories of characteristics of mathematically gifted students’ teachers

Categories	Sub-categories
Personality traits	not having a big ego being open-minded, enterprising etc. being curious especially about mathematics discipline being conscious and highly aware
Knowledge about mathematics	having advanced subject matter knowledge going beyond the content in the curriculum improving themselves with regard to mathematical knowledge having knowledge related to the history of mathematics relating mathematics concepts with other disciplines
Knowledge about gifted education	getting specialized education on gifted students having experience with mathematically gifted students having knowledge to identify the mathematically gifted students following the latest research in the literature

3.1. Mathematics teachers’ personality traits

Most of the participants mentioned personality traits as one of the characteristics of the teachers of mathematically gifted students. They stated that a teacher should *not have a big ego and should be open-minded, enterprising*, etc. One of the dialogues among the prospective teachers explains this view as follows:

PT-2: Sympathetic, progressive, enterprising

PT-7: Sympathetic, absolutely open-minded

PT-3: If not open-minded, there would be ego issues

PT-6: The teacher should not have a big ego

PT-24, in a similar way, emphasized that *not having a big ego* is also essential for gifted students in the classroom by saying “At least the teacher should not feel threatened by the child.” If the teacher sees a gifted student as a threat in the classroom, then both the mathematics teacher and the gifted students do not feel confident their selves. PT-26 explained that mathematics teachers should be *open minded and have a relaxed personality* since it is not a realistic statement to say “We have to know all the answers of gifted students’ questions” and continued as “It is nice for

children to realize that research is a good thing, that not everyone knows everything, that they can reach knowledge by searching, and the teacher may not know.”

A number of the participants proposed that the teachers of a mathematically gifted student should *be curious especially about mathematics discipline*. For example, PT-22 stated that “if mathematics teachers might open to information and have a tendency to investigate in mathematics, then they can be more helpful for the gifted students” and conveyed as follows:

PT-22: Teachers’ consciousness and awareness should be high; I mean social awareness, that is, understanding a gifted student in the classroom can sometimes be very difficult. Thus, the teacher should observe students’ personalities, be a good analyst, and also be responsible for the gifted students.

As seen above, PT-22 highlighted that *being conscious and highly aware* is very important to analyze the characteristics of all the students in the classroom. If the mathematics teachers are good observers, they can determine the potential of both gifted and the other students in their classrooms. Therefore, prospective mathematics teachers also propose that being a responsible person is important for these teachers.

3.2. Mathematics teachers’ knowledge about mathematics

The prospective mathematics teachers explained their thoughts about teachers’ knowledge of mathematics discipline. Almost all of the participants stated that mathematically gifted students’ mathematics teachers should *have advanced subject matter knowledge*. They mainly described a teacher of a mathematically gifted student as one with in-depth knowledge of mathematical concepts. For instance, PT-6’s statement is as follows:

PT-6: We gave an inequality lesson, and then one of the successful students in the class asked a question: “My question about infinity. There are infinite numbers between 0 and 1, and the real numbers are infinite; are these equal?” and then the bell rang. This 9th grade student is constantly asking questions in the class. [...] If I hadn’t taken the Set Theory Course, if I did not know Cantor, real numbers, Aleph-0 or continuum, I wouldn’t have been able to answer that question. [...] The student said: “We say natural numbers are also infinite, but there are fewer numbers in natural numbers than real numbers”. I said “Yes, the infinity of natural numbers is smaller than that anyway. However, if I sit here and tell you this, you will be very confused, so I will not tell you about it, if you are very curious, you can check the works of Cantor”. However, if I did not know, I would not be able to answer the student’s questions in any way.

PT-6 guided the student with her advanced knowledge related to mathematical infinity and answered the student’s question in the teaching experience course. It can be said that the participants emphasized the significance of *going beyond the content in the curriculum* for the teachers of mathematically gifted students. In a similar vein, some prospective teachers stated that the mathematics teachers can use their knowledge of university courses for gifted students. Here are some explanations of the participants:

PT-22: To find the inverse of a number, you have to find the identity element. 1 for multiplication, 0 for addition. [...] The student might ask the question why $-5 + 5$ is 0. Why so? Because 0 is the additive identity. Both are the inverse of each other, I think Algebra is a very useful course when teaching these concepts.

PT-5: The teachers should improve themselves. For example, mathematics is our field, and I have to remember all the concepts that we have discussed in the Introduction to Algebra course. I should be able to teach them even 10 years after my graduation from the university [...] I need to acquire even more advanced knowledge of algebra.

PT-22 associated the mathematics curriculum content with her university courses, such as Algebra. She thought that they would be good sources while attempting to explain mathematical constructs

to gifted students' related questions. PT-5 explained that a mathematics teacher should keep their mathematical content knowledge active as if they were university students even years after becoming a teacher. Here, PT-5 also highlighted that *teachers of mathematically gifted students should improve themselves* with regard to mathematical knowledge. Most of the other participants agreed with PT-5's statement. Besides, prospective teachers proposed that a teacher should not only have in-depth knowledge related to a mathematical concept but also know how this concept has evolved in the history of mathematics. For instance, PT-19's explanation is as follows:

PT-19: The teachers should definitely have full knowledge of the questions they may encounter in the classroom. Besides, for example, we will teach geometry, the child will ask me about where that concept is used, so I need to know the history of that concept, I need to know who was the man who found it; in other words, the history of mathematics. The child may think of questions that will never come to my mind. [...] I think that a child can associate mathematics with other disciplines and ask us questions. I think we should also be able to associate mathematics with other disciplines.

In the way of PT-19's description, the participants believe that a gifted student's mathematics teacher should have *knowledge related to history of mathematics*. Here, PT-19 also stressed the importance of having the knowledge to *relate mathematics concepts with other disciplines* in case of answering gifted students' possible questions. Similarly, PT-16 declared that it is essential to guide a gifted student by saying "I think teachers should be very deep in mathematics; for example, it is important to know that functions are related to artificial intelligence and then to be able to direct the child according to this knowledge."

3.3. Mathematics teachers' knowledge about gifted education

The prospective mathematics teachers claimed that a teacher of mathematically gifted students should have advanced knowledge on giftedness and gifted education. They thought *getting specialized education on gifted students* in the university was essential for the mathematics teachers of the gifted students. PT-19 explained this situation as follows: "We improve ourselves in terms of mathematical knowledge in the university, but I think it is important to have pedagogical courses that consider how we communicate with gifted students [...] I think we have gaps in how to put it into practice." On the other hand, PT-15 suggested that such courses could be organized within the scope of in-service training if such training could not be obtained at the university. She added that it is essential for gifted students' needs and teachers' authority in the classroom. Some of the participants also mentioned that *having experience with gifted students* could also help teachers to get knowledge about mathematical giftedness. For instance, PT-24 declared that spending lots of time with mathematically gifted students can help a teacher understand and improve their knowledge about the characteristics of these students. Similarly, PT-7 pointed out her thoughts *related to both pedagogical and pedagogical content knowledge*:

PT-7: It is not enough to know; it is also important to know how to teach the subject. Yes, we can have enough knowledge to answer the gifted students' questions, but how do I teach or show the right way? Of course, pedagogical formation is essential: we learn how to instruct mathematics in the university. However, the teacher of a mathematically gifted student should know how to instruct that student, it is very important, I think.

As stated above, most of the participants explained that it is not only enough to know the subject matter, it is also important to know how to share this knowledge with gifted students. PT-16, in addition, offered that teachers can use and modify the content of university courses such as problem solving and problem posing for their gifted students. PT-24 also expressed that a mathematics teacher should encourage mathematically gifted students to be curious. The prospective mathematics teachers also mentioned that it is crucial to *have knowledge to identify the mathematically gifted students* in the classrooms for the teachers of the mathematically gifted students. PT-26 said that a teacher should be aware of the mathematically gifted students in the

classroom and have the knowledge to distinguish them from the other students. PT-16 and PT-24 extended this point of view in other aspects:

PT-16: After determining giftedness, I think we should speak with the family about students' actions at home, and also communicate with the other teachers in the teachers' room about the student's actions related to lessons. [...] After that, I think we should give the Olympiad questions to the students in order to see what they can do: Are they good at finding patterns, finding methods? Are they fast at producing formulas? etc.

PT-24: I think teachers should identify the personality of the child very well. They should not only focus on student's success but also consider some of the problems brought on by giftedness.

Here, PT-16 emphasized taking into account the situation of a gifted student in other lessons and at home; besides, she stressed being able to determine the gifted student's tendencies in mathematics. PT-24 underlined that a teacher should have the knowledge to recognize not only the success of gifted students but also the characteristics and possible problematic situations of the gifted students in the classroom.

The prospective teachers proposed that a teacher of gifted students should apply to special institutions such as counseling centers or schools for gifted students, if any, in order to get support. Here is PT-7's explanation: "[...] if there are such institutions, they will be very useful to have a face to face contact in terms of improving our knowledge on the gifted students". Some participants described the ideal teacher of mathematically gifted students as the one who *follows the latest research in the literature*. For instance, PT-5's explanation is as follows:

PT-5: If I were a teacher of a mathematically gifted student, I would not only improve myself in mathematics but also in the educational sciences. I mean I would follow some events like conferences and seminars. If I had a gifted student, I would read articles related to that student and develop a new educational perspective according to these experiences and readings.

4. Discussion

The findings revealed that the participants gave a considerable emphasis on the personality traits of the gifted students' teachers. They stated that being conscious and highly aware, being open-minded, enterprising, and curious, having a relaxed nature, and not having a big ego are some of the traits of these teachers as highlighted in the literature (Chan, 2001, 2011; Davis et al., 2014; Feldhusen, 1997; Leikin, 2011a). For instance, some of the participants argued that if the teachers had a big ego, then they could feel the gifted child as a threat against their authority in the management of the lesson. However, they proposed that if the teacher was a relaxed person, it would be easy to manage gifted students' questions and guide them to research when the teacher did not know the answer. At this point, they also emphasized that being curious to investigate in mathematics and being responsible for the students were also important characteristics for the teachers of gifted students. The participants especially stressed that the ideal teachers of mathematically gifted teachers can adapt themselves regarding their gifted students' cognitive and emotional needs, which is mostly stated in the related literature (Davis et al., 2014; Leikin, 2011a).

Teacher education literature prioritized the importance of content specific knowledge in mathematics and pedagogical knowledge especially related to giftedness (Hansen & Feldhusen, 1994; Karp, 2010; Karsenty, 2014; Leikin, 2011a). In a similar manner, according to the findings of this study, the prospective mathematics teachers stressed the significance of mathematics knowledge of the teachers. Most of the participants thought that the teachers of mathematically gifted students should have advanced subject matter knowledge in mathematics in order to give satisfactory answers to gifted students and be able to go beyond the curriculum subject with them. They offered to use their knowledge from university courses such as Set Theory, Algebra and History

of Mathematics. Some participants highlighted improving the teachers of gifted students as if they were still students and to be open to new topics in mathematics. Relating other disciplines with mathematics was stated as one of the requirements of the teachers of mathematically gifted students. Aside from mathematics knowledge, the majority of the prospective teachers emphasized that it is crucial to have the knowledge of giftedness and gifted students for the teachers of mathematically gifted students. They proposed that the teachers of a gifted student should get education of giftedness in either pre-service or in-service training programs to identify gifted students and guide them correctly. Most prospective teachers also mentioned how having pedagogical content knowledge for teaching gifted students was significant. The participants also emphasized following the new literature and attending the conferences related to gifted education. One of the important findings stated by the participants in this study is that the teachers of gifted students must have experience with gifted students. Similarly, experienced teachers of mathematically gifted stated that being with gifted students improves both teachers' knowledge and creativity (Karp, 2010; Leikin, 2011a). At this point, expert teachers of gifted students can share their experiences with prospective mathematics teachers in the school experience course. It is also important to remember that teacher education does not end with the university (Karp, 2010). When they become mathematics teachers, they will likely meet gifted students in their classroom. In this way, they still have the opportunity to think about the characteristics of gifted students' teachers. Future studies can observe prospective mathematics teachers in both learning contexts.

5. Conclusion

This study investigates prospective mathematics teachers' perspectives about the teachers of mathematically gifted students. The data were gathered from written explanations by prospective mathematics teachers, whole-class discussions, and focus group interviews. It is concluded prospective mathematics teachers predominantly linked education of mathematically gifted students with personality traits of teachers. The participants also considered teachers' pedagogical knowledge and content knowledge. Prospective mathematics teachers emphasized the significance of mathematical content knowledge in the teaching of mathematically gifted students. Having knowledge of giftedness and gifted education was also stressed by the participants of this study.

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