Perceived needs for mathematics among lower secondary students[1]

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This article discusses Turkish students' responses to why they might need mathematics and what mathematics means to them—perhaps questions teachers could ask of their students. Most of the students in this study found mathematics useful or necessary for daily functioning in life.

A student's 'image of mathematics' can be defined as including their attitudes, beliefs, self-concept, motivation, and emotions (Lane, Stynes & O'Donoghue, 2014). The image of mathematics is thought to positively influence: student performance (Wong, Marton, Wong, & Lam, 2002); interest in mathematics (Latterell & Wilson, 2012); and attitudes about mathematics (Picker & Berry, 2001). Across the countries that participate in the Programme for International Student Assessment (PISA) only 38% of students reported enjoying mathematics (OECD, 2016). However, in Turkey the students were more positive.

In previous research (Hatisaru & Murphy, 2019), I examined a large group of Turkish lower secondary students' (N=1284) images of mathematics focusing on students' stated attitudes (Lane et al., 2014; Sam & Ernest, 2000), views about mathematicians and their activities (Sam & Ernest, 2000; Furinghetti, 1993), and perceived needs for mathematics (Sam & Ernest, 2000). Together with a colleague, I later reported on the connections between students' views about mathematicians and their stated attitudes to mathematics (Hatisaru & Murphy, 2019). We found that around 72% of the students' statements "What mathematics means to me" included positive or somewhat positive attitudes to mathematics. Among the remaining group, only 8.7% of students' responses revealed a dislike of or negative statements about mathematics. Similarly, results from Trends in International Mathematics and Science Studies (TIMSS) have shown that, in spite of low scores on achievement testing, Turkish (in this instance, grade eight) students express positive views both about mathematics itself, and learning mathematics, more than students in any of the 39 TIMSS countries (Mullis, Martin, Foy & Hooper, 2015). The motives behind students' attitudes however are not yet clear.

In order to interpret students' attitudes about mathematics, I believe that scholars must produce evidence relevant to the following general questions. What do students find necessary or useful in learning mathematics? And what are the connections between their perceived needs for mathematics and their attitudes, views and feelings about mathematics?

In this article, I provide evidence on these critical issues in mathematics education. The current Turkish context makes it an ideal site for examining these issues, yet the results could be relevant beyond Turkey and informative for the other education contexts internationally. The research question asked is: What views do lower secondary students have about the needs for mathematics? Whether students' attitudes were impacted by their perceived needs for mathematics is also of interest.

Aims for school mathematics

Questions such as, 'Why do we learn mathematics?' or 'What are the benefits of learning mathematics?' rank high among school students across the world. The challenge of answering these questions from students and fostering productive ideas about mathematics are among the major aims of mathematics teaching, and are certainly not trivial. To articulate the need for mathematics to school students, it is necessary to consider what the aims for learning mathematics might be and which capabilities or skills students should develop. Although they are mostly defined in mathematics curriculums (e.g., Ministry of National Education, 2018), many stakeholders in mathematics education may be unclear about both the aims of teaching mathematics and outcomes and benefits afforded by its learning (Ernest, 2015).

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Kilpatrick, Swafford and Findell (2001) developed a framework for the knowledge, skills, competences and beliefs that constitute students' mathematical proficiency and described five desirable mathematical actions for students as outcomes of studying mathematics at school: conceptual understanding (understanding of mathematical concepts and operations), procedural fluency (skill in carrying out procedures accurately and efficiently), strategic competence (ability to formulate and solve mathematical problems), adaptive reasoning (capacity for logical thought, reflection and justification) and productive disposition (seeing mathematics as sensible, useful and worthwhile). Woodward, Beswick and Oates (2018) studied how Kilpatrick et al.'s (2001) mathematical proficiency is portrayed in the *Australian Curriculum: Mathematics*, and stated that while the first four strands are explicitly referenced in the Curriculum, the productive disposition strand (which was defined as encompassing positive attitudes and beliefs about mathematics) is absent.

Ernest (2015) categorised the intended aims and outcomes of school mathematics for students into three groups: The standard aims, unintended outcomes, and visionary goals. Standard aims constitute useful or necessary mathematics for all or some students and intend to develop basic and functional capabilities of students involving:

- functional numeracy (mathematical and numeracy skills necessary for general employment and functioning in daily life);
- work related knowledge (specialist mathematics that certain occupations require; capability to solve practical problems related to those occupations with mathematics); and
- advanced specialist knowledge (necessary for a broad range of university studies including STEM, medical and social sciences).

Unintended outcomes of school mathematics, which coincides with Kilpatrick et al.'s (2001) productive disposition strand, are referred to as the hidden curriculum of schooling and refers to views, values, images, beliefs and attitudes about mathematics that students develop during their school years.

Visionary goals for school mathematics are less utilitarian but more to do with personal, cultural and social relevance and still have strong benefits for students and society in general. This category constitutes:

- mathematical confidence (enjoyment and motivation in learning and using mathematics; being open to challenging problems and persistence in solving them);
- mathematical problem posing and solving (being able to deploy solving non-routine problems as well as posing problems);
- critical citizenship through mathematics (the ability to identify, interpret, evaluate and critique the mathematics represented in different contexts involving the media and social, political and commercial systems); and
- appreciation of mathematics (the appreciation of mathematics itself and its role in history, culture and society) (see Ernest, 2015, for more details).

To define the goals of mathematics teaching, Sullivan (2011) synthesised the work of Ernest (2010) (a previous version of Ernest, 2015) and Kilpatrick et al. (2001), and suggested that for more productive learning in all five of Kilpatrick et al.'s (2001) mathematical actions, Ernest's (2010) perspectives concerning the aims and outcomes of school mathematics for students should be taken into consideration.

Recently, scholars have discussed that 21st century skills such as creativity, problem solving, critical thinking and information literacy (*Assessment and Teaching of 21st Century Skills Project*, 2009) should be an aim for students' learning in mathematics (e.g., Maass, Doorman, Jonker, & Wijers, 2019). Maass et al. (2019) stated that science and mathematics education should be part of citizenship education which echoes Ernest's (2015) visionary goals for school mathematics above.

Aims of the Turkish school mathematics curriculum

In Turkey mathematics is taught as a mandatory and major subject during the lower secondary years of school (Grades 6 to 8, aged 11 to 15 years old), and it is part of both the high school entrance and university entrance exams. Mathematical questions make up 22% of the questions for high school entrance exam and 33% of the questions for the university entrance exam (European Schoolnet, 2018). Parents and students therefore give much importance to mathematics since it helps in the exams that determine to which high school or university a student goes.

The upper secondary school mathematics curriculum (Ministry of National Education, 2018), within the Turkish Qualifications Framework, aims to develop students' eight key capabilities involving the fundamental mathematical and science/technology capabilities, digital competence, cultural awareness, and social and civic skills. The specific aims of the curriculum include explicit references to some of the intended aims and outcomes suggested by Ernest (2015) such as, students will: develop and use mathematical literacy skills effectively; understand mathematical concepts and use them in daily life; develop a positive attitude towards mathematics; express their reasoning in problem solving processes; realise the relationship between mathematics and art, and aesthetics; and value mathematics, being aware that it has a common value for humanity.

The study

As described in Hatisaru (2019), the study reported here was primarily qualitative in which a version of the *Draw a Mathematicians Test- DAMT* (Picker & Berry, 2001) was used to collect data. Combining drawings with written responses, the DAMT consisted of a drawing task and two open-ended questions (Q). Relevant to this article is Q1-b asking students' views about why mathematics would be needed and Q2 probing students' attitudes, views and feelings about mathematics (see Table 1).

Table 1. Open-ended questions in the DAMT.

Q1	If you have a leaky faucet, you need to hire a plumber; if you break your leg, you need the services of a doctor. With this in mind: a. Why would you need to hire a mathematician? b. Why would you need mathematics?
Q2	Please complete his sentence: To me mathematics is:

The sample of 1284 students (aged 12 to 15 years old) was drawn from students enrolled in twenty different lower secondary schools in Ankara. They participated in data collection, under the auspices of the Republic of Turkey Ministry of National Education.

Data analysis

The students' responses to Q2: "To me, mathematics is…" were categorised into six categories to identify their stated attitudes to mathematics by using a schema adapted from Itter and Meyers (2017): Positive, Somewhat positive, Mixed, Somewhat negative, Negative and Neutral. The Positive category included an appreciation or unconditional liking of mathematics statements (e.g., "Enjoyable" and "The best school subject"), whereas the Somewhat negative category included mostly negative (e.g., "Sometimes enjoyable but mostly difficult and boring"), and the Negative category included a strong dislike or hatred of mathematics statements (e.g., "Disgusting, I hate it!" and "Boring and dull") (for more details, see Hatisaru & Murphy, 2019). In this article I have placed the spotlight on the students' responses to Q1-b and report on students' perceived needs for mathematics.

The students' responses to Q1-b: "Why would we need mathematics?" were classified to identify perceived needs in students for mathematics by using a schema adapted from Ernest (2015). Table 2 presents descriptions of each of the outcomes of learning mathematics for students constituting the standard, unintended and visionary aims of school mathematics, and in the Results section examples of representative student statements regarding each outcome are provided.

The data was coded by me. To ensure the validity of the interpretations and data analysis, borrowing from Sam and Ernest (2000), I employed three levels of validity. On the first level, I grouped the similar responses and created sub-groups under the categories in Table 2. For example, many responses to the question on the needs for mathematics were: "We need mathematics for calculations" or "Because there might be things to calculate". I sub-grouped these responses as "For calculation" and categorised them under the Functional numeracy outcome. The other sub-groups under this category were: Useful for everyday life, Arithmetic and Measurement.

Table 2. Schema for classifying students' responses to Q1-b (adapted from Ernest, 2015)

Outcome for students	Description
Functional numeracy	Mathematical and numeracy skills adequate for general employment and functioning in society.
Work-related knowledge	Occupation or work-related mathematics knowledge. The capability to solve practical, occupation-related or industry problems with mathematics.
Specialist knowledge	A foundation for a broad range of further studies at university, including STEM subjects, medical and social science studies.
Images about mathematics	Positive views, values, images, beliefs and attitudes about mathematics and about own mathematical capabilities.
Mathematical confidence	Being confident in the acquisition of new knowledge and skills when needed. Enjoyment in learning and using mathematics. Persisitence in solving difficult mathematical problems; willingness in accepting challenging tasks.
Mathematical problem posing and solving	The ability to solve non-routine problems and problem posing.
Critical citizenship	Being socially and politically empowered citizens in society to identify, interpret, evaluate and critique the mathematics embedded in the media, social, commercial and political systems.
Appreciation of mathematics	The appreciation of mathematics itself, and its role in culture, art and life, and history and society.

On the second level of validity, as some responses contained composite views, I coded them into more than one category. For instance, the responses: "To buy groceries at the market; to enrol in a good high school" were coded into two categories: Functional numeracy and Specialist knowledge.

The third level of validity involved a cross-validation of the coding with two colleagues. The colleagues were given the Schema (Table 2) with 47 representative sample responses and asked to categorise the sample of responses according to their own judgements. I then met with each colleague to check the level of agreement. While there was a great deal of matching in categorisations, less consensus could be reached on the responses referencing the need for mathematics for mental work (f=5). Following Sam and Ernest (2000), I categorised those responses as unintended outcomes of school

mathematics representing students' images of mathematics, readjusted the frequencies for each category in the light of the colleagues' suggestions and developed Table 3 summarising for the perceived needs for mathematics of participant students.

Results

Table 3 shows the frequency of responses corresponding to the aims of school mathematics and the outcome for students for the perceived needs for mathematics for the whole sample, and below I describe the results for each in detail.

Table 3. Students' percieved needs for mathematics corresponded to the aims of school mathematics and outcome for students.

Aims of school mathematics (%)	Outcome for students	Frequency (f)
The standard aims (71.91)	Functional numeracy Specialist knowledge Work-related knowledge	835 98 73
Unintended outcomes (20.87)	Positive images Negative images	262 30
Visionary goals (3.79)	Appreciation of mathematics Problem solving	34 19
Other (3.43)	Obscure No answer	24 24
	Total	1399

The standard aims of school mathematics

Almost 72% (f=1006) of the total responses described the needs for mathematics in terms of the standard aims of school mathematics. Many of these responses (f=835) included references to the Functional numeracy skill and showed that mathematics is perceived to be useful or necessary for everyday life. A total of 517 statements revealed that mathematics was seen as necessary for everyday routines especially for tasks that require calculations or that involve numbers (e.g., reading the clock, dialling a phone number). Statements such as these were often present: "At shopping, banks, school", "Used in every part of our life, even to count the stars" or "In our daily life, for example, when giving or taking money at the bus". Descriptive statements (f=259) such as, "We need mathematics to do calculations in daily life, for example while shopping" or "In all aspects of life; at restaurants, in shopping or purchasing" revealed that mathematics was prominently viewed to be needed in daily life for financial calculations. Several statements involved responses emphasising the needs for mathematics for arithmetic (f=46) (e.g., "To do the four operations" and "To learn numbers") or measurement (f=13) (e.g., "Measuring area of objects" and "To measure circumference, and our height").

Within this group, some students expressed their perceived needs for mathematics in the form of having Specialist knowledge (f=98). Descriptions such as, "To pass the exams, and to have a career", "To be able to enrol in a good high school" or "For university education" suggested that for those who relate the needs for mathematics to further studies at university.

The remaining entries (f=73) in this category referred to the needs for mathematics for certain occupations requiring specialist mathematics such as accounting, banking, medicine or architecture. The following are two representative responses: "There is mathematics in a variety of professions, in jobs such as engineering which require mathematics" and "We will need it in the future when, say, we become a teacher, or for the professions of construction, engineering, tailoring, and tourism".

Unintended outcomes of school mathematics

Over 20% of the responses (f=292) reflected unintended outcomes of school mathematics. While several students indicated negative images about mathematics (f=30) such as, "I don't need it" or "I don't know, and personally, I am not interested", many students seemed to have positive images. The students' images were predominantly related to their attitudes (f=223) but in several cases they related to the process of learning mathematics (f=39). In the former group, most students found mathematics to be very important or useful. Some typical statements included: "Essential" "Very important" and "Very important and necessary subject". The latter group viewed mathematics as mental or logical work suggesting that they relate mathematics to learning: "To reinforce our brain and mental capacity, to do calculations, to keep our brain active" and "To develop our logic".

Similar evidence had been found in students' responses to Q2. Only a small number of student responses to the prompt "What mathematics means to me" revealed a dislike of (f=112) or somewhat negative attitude toward (f=90) mathematics. Rather, almost 72% of student statements included positive or somewhat positive feelings to mathematics. Many of these descriptions showed that the students did like mathematics. Statements such as, "Enjoyable", "Very important", "A hobby" and "Superior" were often used by the students (see Hatisaru & Murphy, 2019).

Visionary goals of school mathematics

Approximately 3.5% of the responses were in the visionary goals category (f=53), making it a less populated category. Within this category, some responses (f=34) reflected a bigger picture view of why mathematics would be needed, and were coded as: Appreciation of mathematics. Some representative descriptions such as, "There would not be robots, machines, if it weren't for mathematics" or "Universe is founded on mathematics"

reflected a sense of mathematics as underpinnings science and technology.

Several other statements (f=19) indicated that some students believed that mathematics is necessary for problem solving (e.g., "To solve problems" and "Mathematics is a must in daily life, problems are solved by means of mathematics"). Although the types of problems were not made explicit in those statements, considering that in the Turkish context the word 'question' is usually used for routine problems, these entities were categorised as Problem-solving, if the students referred to non-routine real-life problems. The remainder of around 3.5% of responses either included obscure descriptions (e.g., "Otherwise, it would be rude to the numbers" and "Because mathematics does not need us") or remained unanswered.

Summary and concluding remarks

This analysis showed that the perceived needs for mathematics in students in this study were closely related to the standard aims of school mathematics. The majority of students found mathematics useful or necessary for functioning in daily life. Many related their perceived needs for mathematics to the basic everyday life tasks that require calculations (e.g., using arithmetic, or making financial calculations), and some of them related to the need for mathematics to work, or study at university. Only about 3.5% of responses related the need for mathematics to the visionary goals of school mathematics, the most popular one being the perception that mathematics permeates and underpins science and technology (Ernest, 2015). The 'Social empowerment through mathematics' outcome of learning mathematics was absent from student responses to why mathematics would be needed.

Strong evidence of positive attitudes about mathematics was found in students' responses to both Q1-b analysed in this article, and to Q2 presented in Hatisaru and Murphy (2019). This finding may imply that the participant students had developed positive attitudes and views about mathematics during their years of schooling. Being numerate or succeeding in high school or university entrance exams were the main motives for students, and their positive attitudes might be as a result of these perceived needs. Although developing positive attitudes or views about mathematics is important in achieving these standard aims of school mathematics, for students to attain greater achievement and success, we need to adopt broader and more visionary goals for school mathematics (Ernest, 2015).

The findings of the present study highlight the wide range of perceived needs for mathematics of a large group of Turkish lower secondary school students. The study has limitations. For instance, I acknowledge that within their responses to an open-ended question, some students might not be as reflective as they could have been in interviews. Nevertheless, the rich variety of perceived needs for mathematics in these students has illustrated the possible utility of student views analysis as a means to gain insight into mathematics teaching in classrooms. Additionally, the perceived needs for mathematics highlighted in this study may indicate the variety of mathematics learning experiences for students in mathematics classrooms. My recommendation is that we need to direct more attention and research to this area so that how the visionary aims of school mathematics and outcomes for students could be improved in mathematics classrooms.

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