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"Mathematics is like a lion": Elementary students' beliefs about mathematics

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Abstract The aim of this study was to explore the beliefs of elementary school students about mathematics and about themselves as mathematics learners. The participants, Israeli grade 4 and grade 6 students, completed questionnaires. Using an "animal metaphor" to tap beliefs, some students perceived mathematics as difficult and complicated, while for others, mathematics was connected to wisdom. The data from other questionnaire items indicated that students at both grade levels generally did not enjoy learning mathematics, but believed it was very important to study this subject. They also believed that they were good at mathematics, but the grade 6 students' self-perceptions of achievement were lower than those of the grade 4 students. Compared to the boys, the girls in both grades 4 and 6 expressed lower perceptions of their mathematics achievement levels.

Keywords Beliefs · Mathematics · Gender · Metaphors · Elementary students

1 Introduction

The relationship between mathematics and gender is a topic that has been researched by mathematics educators, psychologists, and sociologists. In general, tertiary level faculties of science and engineering worldwide are mainly staffed by men. Some research studies indicate gaps in mathematics achievement between girls and boys. In many countries boys outperform girls, in some there is no difference, and in a few countries girls outperform boys (e.g., Mullis, Martin, Foy, & Arora, 2012; OECD, 2015).

The gender gap favoring males is partially explained by two main factors. Some claim that it is due to innate biological differences between men and women, while others claim that the gap is due to social and environmental factors (e.g., Leder, 1992). With little evidence

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supporting the genetic explanation (no gene has been identified), and the TIMSS and PISA results clearly providing contrary evidence, the psychosocial models for explaining the gap, which also are more promising with respect to the potential for change, are more convincing. There is much consistent research evidence of differences in the beliefs of girls and boys towards mathematics. Boys are frequently found to have more functional beliefs (that is, more likely to lead to success). Particularly in western countries, boys, for example, are found to be more confident than girls in their mathematical capabilities, see mathematics as being more useful to them with respect to future career paths, are more likely than girls to believe that mathematics is a study more suited to males (male domain), and generally believe that they are better at mathematics than girls (e.g., Forgasz, & Leder, 1996; Leder, 1992; Vale, & Bartholomew, 2008).

The aim of this study was to examine Israeli elementary students' (grades 4 and 6) beliefs about mathematics and their self-perceptions of mathematics achievement levels. Whether there were gender and grade level differences were of particular interest. Much previous research on beliefs about mathematics has focused on older students' beliefs. In this study we examined the beliefs of elementary school students in order to determine whether they, at such an early stage of schooling, already displayed beliefs consistent with those identified in previous research. One means to reveal beliefs is through the use of metaphors (Schinck, Neale, Pugalee, & Cifarelli, 2008). Earlier studies adopting metaphors to reveal beliefs towards mathematics have been conducted mostly with pre-service and practicing mathematics teachers. Unique to this study was the use of an animal metaphor to gauge students' beliefs about mathematics, and the focus on elementary level students' beliefs.

2 Theoretical frameworks

2.1 Gender differences in mathematics learning outcomes

Over time, there have been several explanatory models postulated to account for gender differences in mathematics learning outcomes – achievement, participation, and attitudes/beliefs. Leder's (1990) model included two main categories of variables – learner-related (e.g., cognitive development, beliefs) and environmental (e.g., society, home, and school). These categories, and the variables included, remain central to on-going research in the field. The model is founded in expectancy-value theory as it pertains to education more broadly, and to mathematics education in particular (see Eccles, 1983); *expectancy* relates to individuals' confidence in succeeding at tasks, and *value* to the perceived importance, enjoyment, and usefulness of tasks. The variables included in Leder's (1990) model informed the development of the research instrument used in this study, and in the analyses of the data.

2.2 Metaphors in educational research

Lakoff (1992), a cognitive linguist, described metaphors as "the way we conceptualize one mental domain in terms of another" (p. 1). According to Midgeley and Trimmer (2013), "Metaphors can be useful conceptual tools for, in and of education research. One common use of metaphor in education research is to illustrate or explain a concept in a way that will communicate effectively to the intended audience" (p. 1). Another way of viewing the metaphor genre is a means by which a comparison is made between two non-connected issues which may share common characteristics.

With respect to mathematics education, Soto-Andrade (2014), described how metaphor has been used, claiming that they have been recognized as "powerful cognitive tools that help us in grasping or building new mathematical concepts" (p. 447). Building on the work of Lakoff and colleagues, Chapman (1997) maintained that "metaphors are more than linguistic devices. They represent embodied knowledge grounded in experience" (p. 209), thus providing insight into beliefs held. Metaphors have been used to reveal beliefs about mathematics and its teaching, mainly through explorations of pre-service (e.g., Erdogan, Yazlik, & Erdik, 2014; Latterell, & Wilson, 2016; Leavy, McSorley, & Boté, 2007; Noyes, 2006; Reeder, Utley, & Cassel, 2009) and practicing teachers' (e.g., Chapman, 1997, Oksanen, & Hannula, 2012) perceptions. There has also been some research unpacking students' beliefs about mathematics (e.g., Schinck et al., 2008) through metaphor.

For this study, we drew on an item that had been used by Miller-Reilly (2000) in interviews with adult learners of mathematics at the university level. Miller-Reilly (2000) maintained that the use of the "animal metaphor" had the potential to reveal beliefs about mathematics as respondents expressed their views through the description of an animal. In addition to the "animal metaphor", Miller-Reilly (2000) used other metaphors such as "weather", "kitchen utensil", "tool" and "travel" to gauge participants' beliefs. Because we were working with elementary-aged students who would know something about a range of animals, we believed that the "animal metaphor" would work best. Moreover it seemed to us that the "animal metaphor", rather than a non-specific metaphor, might better reveal students' feelings about mathematics.

3 Previous research

3.1 Beliefs about mathematics

Forgasz and Leder (2008) claimed that "studies on beliefs about mathematics and mathematics teaching and learning have been a relative new addition to the mathematics education research agenda" (p. 173). Goldin, Rösken, and Törner (2009) emphasized the importance of beliefs in the mathematics teaching and learning process and noted that "...beliefs matter. Their influence ranges from the individual mathematical learner and problem solver, and the classroom teacher, to the success or failure of massive curricular reform efforts across entire countries" (p. 14). Much of the research on beliefs has focused on beliefs about the nature of mathematics, beliefs about pedagogy and learning, about technology, about gender and equity issues, and about aspects of mathematics achievement (Forgasz, & Leder, 2008).

Students' beliefs about mathematics might influence the way they see mathematics and the way they learn the subject. For example, in his research among 230 mathematics students in the United States, Schoenfeld (1989) found that students believed that mathematics is mostly memorizing, but on the other hand they said that it is a discipline which is creative, useful and teaches thinking. Beliefs about mathematics learning have also been found to be connected to mathematics achievement. House (2006) conducted a study with elementary school students who participated in the Third International Mathematics and Science Study in 1996. He examined the relationships between mathematics beliefs and achievement among 8220 elementary school students in Japan and 10,070 elementary school students in the United

States. The findings suggested that in both countries students who believed that to succeed in mathematics one had to work hard and study at home had higher scores in mathematics tests than students who did not hold such beliefs. Students with low scores in mathematics saw mathematics as boring, and attributed success in mathematics to natural talent. Beliefs about mathematics also appear to be connected to culture. House (2006) found that Japanese students with high scores tended to attribute success to memorizing the textbooks or the notes, while in the United States students with such beliefs tended to show low mathematics achievement. House suggested that one of the explanations of this is cultural differences between the two countries in the use of memorization in mathematics education.

In a large number of studies, beliefs among prospective and practicing teachers have been explored (Forgasz, & Leder, 2008). For example, in their research among 398 elementary school teachers in Australia aimed at examining teachers' beliefs about teaching, learning, and assessing mathematics, Nisbet and Warren (2000) used factor analysis. They found that some teachers had a static view of mathematics and others had a mechanistic view, while the dynamic problem-solving view did not form a factor. Two approaches to the teaching of mathematics were identified: a constructivist approach, and a transmission approach. Three major purposes of assessment were also identified: to inform the teacher, the learner, and for accountability.

In several studies, metaphors have been used to unpack beliefs about mathematics. For example, in the United States, Reeder, Utley, and Cassel (2009) used metaphors to examine 200 elementary school preservice teachers' beliefs about mathematics teaching and learning at three different points during their mathematics education method courses. They found that in spite of ongoing experiences to challenge and extend their beliefs, the elementary school preservice teachers' beliefs remained static. Latterell and Wilson (2016) also conducted a study among preservice elementary teachers in the United States in order to investigate what metaphors preservice teachers use to describe mathematics and to describe the learning of mathematics. The metaphors provided by the 93 participants revealed twelve different categories of beliefs: about a quarter of the metaphors suggested negative views of mathematics and the learning of mathematics.

Schinck et al. (2008) conducted a study of the mathematics beliefs of 34 students in grades 9 and 10 in the United States. The metaphors suggested that students viewed mathematics as an interconnected structure, a hierarchical structure, a journey of discovery, an uncertain journey, and as a tool. The metaphors also revealed that students believed that perseverance is needed in order to succeed in mathematics.

3.2 Gender and achievement in mathematics

In recent years, researchers have continued to examine the gender gap in mathematics achievement. The findings are not uniform and can depend on the age of the participants, on the research approaches adopted, on the data used, and on the analyses of the results. In western countries, however, most continue to reveal differences in achievement in favor of boys or in some cases, no gender difference; rarely are differences favoring girls reported.

Cultural, societal, and ethnic factors play a role in whether gender differences in mathematics achievement are found or not. Else-Quest, Hyde, and Linn (2010) conducted a meta-analysis of two major international data sets: 2003 Trends in International Mathematics and Science Study [TIMSS], and the 2003 Programme for International Student Assessment [PISA] "to estimate the magnitude of gender differences in mathematics achievement, attitudes, and affect across 69 nations throughout the world” (p. 103). They concluded that overall, on average, males and females differed little in mathematics achievement, although there were substantial gender gaps in some countries, but not in others. Males, however, were found to hold more positive attitudes towards mathematics than females. They also identified specific gender equity domains which vary from country to country which contribute to these gender gaps; the most powerful predictors were: gender equity in school enrolments, “women’s share of research jobs, and women’s parliamentary representation” (p. 103).

In addition, Marks (2008) looked at the PISA 2000 results of students from 31 countries in reading and mathematical literacy. For most countries it was found that girls outperformed boys in reading but that the boys outperformed girls in mathematical literacy. Guiso, Monte, Sapienza and Zingales (2008) examined PISA 2003 results in reading and mathematics literacy and noted that in many countries girls’ achievements in mathematics were lower than boys’, but that in countries like Sweden, Denmark and Norway there were no gender differences. The researchers claimed that when girls live and learn in an equitable society their mathematics achievements are equal to, and sometimes better than boys’, and that the gender gap does not exist in countries where women have equal opportunity and equitable access to resources. However, a gender gap in mathematics achievement favoring boys was also found in the 2012 PISA in many of the participating countries:

> In 2012, boys outperformed girls in mathematics in 38 participating countries and economies by an average of 11 score points (across OECD countries)… However, among the top 10% of students in mathematics performance, the gender gap averages 20 score points. (OECD, 2015, p.20)

In particular, for Israel, the 2012 PISA results reveal a gender gap in favor of boys in the Jewish educational sector, but in favor of girls in the Arab sector (National Authority for Measurement and Evaluation, 2013).

For grade 4 TIMSS 2011, Mullis et al. (2012) reported no gender differences in mathematics achievement in 26 out of the 50 participating countries. Small gender differences favoring boys were noted in 20 countries; in four countries (Qatar, Thailand, Oman, and Kuwait) relatively larger differences were found in favor of girls. For the grade 8 TIMSS 2011, there were no gender differences in mathematics achievement in 22 out of the 42 participating countries, boys outperformed girls in seven countries, and girls outperformed boys in 13 countries. At both grade levels in TIMSS 2011, the largest gender differences in mathematics achievement favoring girls were found in Arabic speaking countries from the Middle East.

In an extensive study conducted with 29,171 grade 9 students in Germany, it was found that there were small differences in favor of the boys when a particular statistical model was used to analyze the results, and bigger differences in favor of boys when a different statistical model was used (Brunner, Krauss, & Kunter, 2008). In another study, the mathematics achievements of males and females in China and in the USA were compared (Tsui, 2007). No achievement differences were found for grade 8 in the two countries. In college entrance examinations, however, there were no gender differences in China, but in the USA a gap was found in favor of the males. In reviewing the achievements of excellent mathematics students who had entered college, a gender difference was found in favor of males in both countries.

Gender gaps favoring boys in mathematics achievement have been reported for very young children. Penner and Paret (2008), for example, found gender differences in mathematics favoring boys in the early childhood years. Family background was found to play an important role with respect to this gender gap. The researchers argued that these differences could not be explained by biological differences between boys and girls, but were more likely to be rooted in socio-cultural differences.

In a review of the research in the field, Spelke (2005) argued that the findings from studies conducted with infants, preschoolers and students of all ages do not support the claim that there are innate differences between girls and boys in relation to mathematical and scientific capabilities. Rather, it has been found that infants, boys and girls, learn about objects, numbers, language and space in the same ways and at the same time developmentally. Later, gender differences are found with respect to various capacities, but the differences are not always obvious, and it is therefore impossible to claim that females are more *verbal* and males more *spatial*. Spelke (2005) also claimed that there are no cognitive gender differences for mathematical or scientific capabilities. On the contrary, there is evidence indicating that males and females develop mathematical and scientific capabilities similarly. The explanation for any gender gap in mathematics achievement favoring males that exists appears to be founded in social-cultural norms and expectations.

Yet another reason for the gender gap in mathematics achievement favoring males is related to gender differences in preferred learning styles. Compared to males, females are less likely to enjoy lectures and competitive activities, and more likely to prefer small group discussions and exploring ideas in depth (e.g., Geist, & King, 2008). Geist and King (2008) also claimed that these differences are not accounted for in the curriculum, or by teachers of mathematics.

3.3 Gender and attitudes towards and beliefs about mathematics

Mathematics is considered a difficult and complex subject and has been viewed as a male domain, that is, more suited to males than to females (e.g., Leder, 1992). It is a subject for which attitudes and beliefs impact on the desire to learn, on achievements and, longer term, on participation in higher level studies and career paths. Gender differences in attitudes towards mathematics and beliefs about self as a learner of mathematics are well documented and have a long history (see, for example, Leder, 1992; Leder, Forgasz, & Solar, 1996). Compared to females, males are more likely to say they enjoy mathematics, find it interesting and useful, and express greater confidence in their own mathematical capabilities (e.g., Forgasz, & Leder, 1996; Lupart, Cannon, & Telfer, 2004). In many countries, people have been found more likely to consider males than females to be good at mathematics; in some countries, this pattern of gender stereotyping of mathematics was much stronger than in other countries (Forgasz, Leder, & Tan, 2014). In studies founded in Weiner's attribution theory (Weiner, 1974), it has consistently been found that males are more likely than females to attribute success in mathematics to 'natural' (innate) ability, while females are more likely than males to attribute success to effort. On the other hand, for failure in mathematics, males are more likely than females to indicate that they did not work hard enough, while females are more likely than males to say that it is because they are not good at mathematics; for an overview of early work in this field see Leder (1992). More recently, in a study in which 45 high school students with high mathematics and science achievements were interviewed, Dentith (2008) found that the girls felt that, because they were girls, they needed to work very hard to match boys' achievements.

Gifted girls might also hold low self perception regarding mathematics. Preckel, Goetz, Pekrun, and Kleine (2008) examined the mathematical skills, academic self-concept, interest and motivation towards mathematics of 181 gifted and 181 average ability grade 6 students. The study found no gender differences in the students' mathematical achievements, but found that compared to the boys, the girls had lower academic self-concept, interest, and motivation. These differences were greater among the group of gifted students.

Mullis et al. (2012) presented findings on the affective/attitudinal items from the TIMSS 2011 testing. Over time, a strong positive relationship had been identified between attitudes towards mathematics and mathematics achievement. However, Mullis et al. (2012) did not report the attitudinal data by gender. For the Australian TIMSS 2011 results, attitudinal item results were reported by gender for grade 4 students (Thomson, Hillman, Wernert, Schmid, et al., 2012) and grade 8 students (Thomson, Hillman, & Wernert, 2012). At grade 4, it was found that a higher proportion of male (48%) than female (43%) students *like learning mathematics*, and that male students (42%) tended to be more confident with mathematics than females (33%). For grade 8 students, a higher proportion of male (18%) than female (14%) students like learning mathematics, with a statistically significantly higher proportion of females (48%) than males (41%) in the *do not like mathematics* category. Males were reported to value mathematics to a greater degree than females, and there were no statistically significant gender differences in the *Confident with Mathematics* categories.

The Israeli TIMSS 2011 results at grade 8 revealed that 26% of the Israeli students *like mathematics*, and 61% of the students *value mathematics*; this was higher than the international average for participating countries. With respect to *confidence with mathematics* Israeli students were ranked first, with 31% of the students reporting that they were confident in their mathematical abilities, compared with the average of 14% among all participating countries. Among the Hebrew speaking Israeli students, males held slightly more positive attitudes towards mathematics than females; among the Arabic speaking Israelis, females held much more positive attitudes that males (National Authority for Measurement and Evaluation, 2012).

As revealed in the literature review, attitudes towards, and beliefs about mathematics, as well as individuals’ perceptions of their mathematics capabilities are shaped by many societal, home, and school factors, they vary by country, and these patterns may be evident in the early years of schooling. In this study we examined the beliefs of Israeli grade 4 and grade 6 girls and boys about mathematics, as well as gauging their academic self-concepts with respect to mathematics.

4 The study

4.1 Research approach

The research tool **was a questionnaire** The questionnaire included 14 items, some open, some half-open (in which students were asked to make a selection from a number of possible responses and then explain their choice), and others were closed. The items were related to four main themes: students’ beliefs about mathematics (e.g., Draw a picture of, or describe in words, a person who is using mathematics at work), self-perceptions of academic achievement in mathematics (e.g., How good are you at mathematics?), beliefs about the relationship between gender and mathematics (e.g., In your opinion, who teaches mathematics better, a female or a male teacher?), and beliefs about teachers’ and parents’ perceptions of mathematics and of gender issues in mathematics education (e.g., Is it important to your parents for you to be good in mathematics?). The questionnaire was anonymous, but students were asked to specify their sex (boy/girl). In this study we analyzed only eight items out of the 14 included in the questionnaire.

The sample comprised 281 grade 4 and grade 6 students from five elementary schools in Israel. Overall, there were 134 grade 4 students (73 girls, 61 boys) and 147 grade 6 students (70 girls, 77 boys).

Analyses SPSS was used to analyze the closed and half open items. Descriptive statistics were complemented by ANOVAs to explore for statistically significant differences by student sex and grade level. Qualitative techniques were used to analyze responses to the open items and the explanations students provided to the half open questions. Previous research findings guided the identification of themes in the students' written responses. In addition, the researchers were open to unanticipated categories that emerged from the data.

4.2 Findings

In this article, we focus on the findings from only one of the open items as well as some of the closed items. These items had been designed to elicit students' beliefs about mathematics and their perceptions of their own mathematics achievement levels.

4.2.1 What animal do you think math is like? Explain (open item)

This question was answered by 86% of all students (242 students). Students referred to a variety of animals, mentioning more than 60. The animals which were identified multiple times were: monkey (35), dog (21), cat (16), owl (13), dolphin (12), elephant (12), snake (9), lion (7), zebra (6), human (6); several other animals mentioned by fewer than six students included: tiger, ant, bee, turtle, horse, hedgehog, parrot, bird, fish, kangaroo, hedgehog, chameleon, lama, penguin, mammoth, bear, donkey, fly, mosquito, tick, hippopotamus, and bacteria. There were no gender or grade level patterns of differences identified in the choice of animal.

Explanations for the choice of animal were provided by 231 of the 242 students who named an animal. A summary of the categories that emerged in the reasons students chose particular animals, by grade level and sex of student, is presented in Table 1.

Table 1 Categories or explanations for choice of animal, by grade level and sex (% students)

Explanation	Boys Grade 4 (*n* = 50)	Girls Grade 4 (*n* = 59)	Boys Grade 6 (*n* = 61)	Girls Grade 6 (*n* = 61)	All (*n* = 231)
Relates mathematics to wisdom	18	31	20	33	26
Connects mathematics to the external features or characteristics associated to the animal	12	19	33	11	19
Negative connotations of mathematics	16	8	18	10	13
Conceptions of mathematics and its teaching or learning	10	5	10	16	10
Links mathematics to people – important to people and people learn it	10	7	7	15	10
The animal uses mathematics or can be taught mathematics	16	7	2	3	6
Expresses love or ambivalence towards mathematics	8	7	2	5	5
Something else	10	16	8	7	11

From Table 1 it can be seen that more than a quarter of the students (26%) conceived of the need to be smart or wise to work and succeed at mathematics. Examples included:

> Cat. Because the cat is a smart animal. (boy, grade 4)
>
> Lion. Mathematics is like a lion because mathematics is for smart people, and the lion is smart. (girl, grade 4)
>
> Elephant. I think elephants are very wise because of their wonderful way of life. (girl, grade 4)
>
> Dolphin. Dolphin is an intelligent animal. (boy, grade 6)
>
> Rat. Because the rat is a very smart animal, and laboratory experiments have also suggested it is very smart. (boy, grade 6)
>
> Owl. Because the owl is a smart animal, like the people who are engaged in mathematics. And it is as accurate as mathematics is. (girl, grade 6)
>
> Rabbit. The rabbit with glasses from Alice in Wonderland. He looks wise. (girl, grade 6)

It was interesting to note that the percentages of girls who linked mathematics to being clever or wise was higher than the percentages of boys at both grade levels (grade 4: 31% cf. 18%; grade 6: 33% cf. 20%). This suggests that girls may be more likely than boys to believe that a person has to be (naturally) smart to engage with and/or succeed in mathematics.

Connections between mathematics and the external features or the behavior of the animal were the reasons provided by 19% of the students, with a higher proportion of grade 6 boys (33%) providing responses in this category. Examples included:

> Dog. Because if you have a Dalmatian and you want to count its spots you need to know mathematics. (boy, grade 4)
>
> Zebra. Because you can count the stripes. (boy, grade 4)
>
> Kangaroo. She jumps every day from 10 to 12 and 12 to 14 [some mathematics textbooks use the kangaroo to illustrate the use of a number line]. (girl, grade 4)
>
> Cat. Because it has 9 souls. (girl, grade 4)
>
> Snake. It is as long as the numbers are. (boy, grade 6)
>
> Cat. Because when a cat mates, a kitten is born, and then more and more kittens are born and it’s like chain… (boy, grade 6)
>
> Sheep. You always count up 100 sheep before you go to bed. (boy, grade 6)

Negative feelings towards mathematics were expressed by 13% of the students in the explanations they provided for their choice of animal. Higher percentages of boys than girls at both grade levels expressed negative views (grade 4: 16% cf. 8%; grade 6: 18% cf. 10%). Examples included:

Skunk. Because math irritates and stinks. (boy, grade 4)

Bull. Because the bull is upset because of the hard level in mathematics. (boy, grade 4)

Spider. Because it's annoying and ugly, just like mathematics. (girl, grade 4)

Snake. Its poison is like very difficult exercises. (girl, grade 4)

Sea urchin. Sea urchins sting you. You go to the hospital and it ruins your day, and when one hears mathematics, it also ruins your day. (boy, grade 6)

Penguin. Because I don't like math. I think mathematics is cold like the penguin. (girl, grade 6)

Conceptions of mathematics – difficulty and elegance – and related expectations of how the subject is taught or learnt – speed, effort/diligence, and persistence – were expressed by 10% of the students in their explanations for their choice of animal, with a higher proportion of grade 6 girls' explanations (16%) found in this category. Examples included:

Horse. The horse is always fast and galloping ahead like mathematics. (girl, grade 6)

Cheetah. Because you have to move very fast like the cheetah, from topic to topic to meet requirements. (girl, grade 4)

Chameleon. Mathematics switches topics all the time, just as the chameleon switches colors. (boy, grade 6).

Bear. Because mathematics has to be learned very very slowly. (boy, grade 6)

Ant. To learn mathematics you have to be as industrious as an ant. (boy, grade 6).

A man. Because man develops all the time and so does mathematics. (boy, grade 4)

Bird. Mathematics is a noble field, and is high in the sky without putting too much effort in it. (girl, grade 4)

Giraffe. Because the exercises are long and the giraffe is tall. (girl, grade 6)

Parrot. The parrot repeats everything it hears. In mathematics you need a lot of repetition if you want to understand the material. (girl, grade 6)

In their explanations for the choice of animal, 10% of students linked the animal's characteristics to the importance of mathematics to humanity, and the need and the capability of humans to learn mathematics. Compared to the other groups of students, this category of explanation was more common among grade 6 girls (15%). Examples included:

> Monkey. I think the monkey, many years ago, was in the place of humans and is the most appropriate animal for mathematics. (girl, grade 4)
>
> Cow. Mathematics is important to people and so is the cow who produces milk. (boy, grade 4)
>
> Elephant. Because mathematics is important and affects life as the elephants affect the area where they live, (boy, grade 6)
>
> Giraffe. The giraffe is very tall and, like its height, is equal to the importance of mathematics in our lives. (girl, grade 6)
>
> Dog. Because the dog helps us just like mathematics does. (girl, grade 6)

A small group of students (6%) only chose animals which, in their opinions, use mathematics or can be taught mathematics. What can be inferred from their explanations is that there is possibly some innate human capability for mathematics, as with these animals. Examples included:

> Dog. The dog can be taught mathematics. I saw a dog on TV who calculated exercises (boy, grade 4)
>
> Bird. Migratory birds know exactly where they fly and how many miles they fly, and they calculate when to land and when to rest and when to continue to roam. (boy, grade 6)

Table 2 Mean scores for students’ enjoyment and perceived importance of mathematics, and self-perceptions of achievement – by grade level and sex

	Gr4 $n = 147$	Gr6 $n = 134$	M all $n = 138$	F all $n = 143$	Gr4 M $n = 61$	Gr4 F $n = 73$	Gr6 M $n = 77$	Gr6 F $n = 70$
1. Enjoy learning mathematics	3.35	3.23	3.30	3.27	3.35	3.34	3.26	3.2
2. Importance of learning mathematics	4.46	<u>4.71</u>*	4.57	4.60	4.46	4.47	4.69	473
3. How good are you at mathematics?	<u>4.25</u>	3.94**	<u>4.27</u>	3.91**	4.47	4.03	4.08	3.8
4. How good at mathematics would you like to be?	4.64	4.69	4.68	4.64	4.6	4.7	4.78	4.6
5. How good do you think your teacher believes you are at mathematics?	<u>4.19</u>	3.82**	<u>4.13</u>	3.88**	4.4	3.99	3.86	3.77
6. How good do you think your parents believe you are at mathematics?	<u>4.43</u>	4.14**	<u>4.40</u>	4.17**	4.54	4.34	4.25	4.03
7. How good do you think your classmates believe you are at mathematics?	<u>4.11</u>	3.83**	3.98	3.97	4.1	4.13	3.85	3.81

* $p < 0.05$ ** $p < .01$

Underlined scores indicate the higher mean for statistically significant score difference

Bird. The (female) bird is sitting on the eggs and she needs to know how many eggs she has in the nest, and if she flies from the nest and then gets back she has to count how many eggs there and she always notices if an egg is missing. (girl, grade 6)

A further small group of students (5%) chose an animal they liked, and explained that they liked mathematics, or chose an animal that represented and reflected their ambivalence towards mathematics. Grade 4 boys (16%) were more likely than the other groups of students to provide explanations in this category. Examples included:

Dog, I think mathematics is like a cute dog. (boy, grade 4)

Elephant. Because I love elephants. (boy, grade 4)

Bat. Because there are those who love bats and are interested in bats and those who hate bats and barely approach them. (girl, grade 4)

Dog. Dogs help people and mathematics also helps people, but sometimes it's hard to be with a dog and sometimes it is hard to do mathematics. (girl, grade 6)

The responses of 13% of the students were difficult to classify and were quite varied. Quite a few of these students simply justified their choice of animal by saying, “That’s what I think”, or “This is the first animal which jumped into my mind”.

4.2.2 Enjoyment and importance of mathematics, and self-perceptions of achievement

The students were asked to indicate the extent to which they enjoyed learning mathematics and how important it is to learn mathematics. These were closed items with 5-point response formats: 5 = “enjoy very much” and “very important”, and 1 = “do not enjoy at all” and “not at all important”.

They were also asked to indicate on 5-point response formats (5 = excellent to 1 = poor) how good they believe they are at mathematics, how good they would like to be at mathematics, and how good they believe others (parents, teachers, and classmates) think they are at mathematics. The mean scores by grade level and sex, and statistically significant differences (ANOVA results), are shown in Table 2.

With a mean slightly above 3, the data in Table 2 suggest that students do not much enjoy learning mathematics (Item 1). While not statistically significantly different, grade 4 students (3.35) indicate slightly greater enjoyment of mathematics than grade 6 students (3.23), and overall, as well as within grade level, there were no gender differences.

As to the students’ perceived importance of studying of mathematics (Item 2), it was clear that, overall, students believe that it is very important (means > > 4). The statistically significant higher level of perceived importance by grade 6 students compared to grade 4 students is noteworthy. For this item, there were no statistically significant gender differences overall or within grade level, strongly suggesting that both girls and boys consider the study of mathematics to be important.

The mean scores for students’ beliefs about their mathematics achievements (Item 3) indicate that, on average, grade 4 students perceive themselves to have significantly higher mathematics achievement (4.25) than grade 6 students (3.94). This suggests that perceived mathematics achievement may decrease as grade level increases. The data also show that, overall, boys’ perceived mathematics achievement levels (4.27) are significantly higher than girls’ (3.91), and this pattern, while not statistically significant, is also apparent at each grade level.

When the mean scores for Items 3 and 4 are compared, higher mean scores were found for Item 4. This indicates that all students (boys and girls) would like to be better at mathematics than they currently believe they are. There were no gender differences in the mean scores for desired levels of mathematics achievement (Item 4).

Interesting patterns can be seen in the responses to Items 5, 6, and 7 which relate to the students’ perceptions of how good they believe their teacher’s, their parents’, and their classmates (respectively) think they are at mathematics. For each of these items, the mean score for grade 4 students is statistically significantly higher than for grade 6 students. For Items 5 (teacher) and 6 (parents), the mean scores for boys were statistically significantly higher than for girls, but for Item 7 (classmates), there was no gender difference. Also noteworthy is that at both grade levels, and for both boys and girls, the students indicated that they believed their parents think they are better at mathematics (Item 6) than their teachers do (Item 5). Interestingly, too, at both grade levels, and for both boys and girls, the students perceive their own mathematics achievement levels (Item 3) to be higher than what they believe their teachers think are their achievement levels (Item 5), and lower than what they believe their parents think (Item 6). When students were asked how good at mathematics they believed their classmates believed they were, the mean ratings by boys and by girls were not significantly different. Both believed they would be considered very good at mathematics (boys: 3.98; girls: 3.97). Comparisons of boys’ ratings of their classmates’ beliefs about their achievement levels (3.98) with their self-ratings of achievement (4.27) and their beliefs about teachers’ (4.13) and parents’ ratings (4.40) of their achievement level are intriguing; the comparisons suggest that boys believe that their parents and their teachers will concur with their own high self-ratings of achievement, yet classmates will not rate them as highly. On the other hand, girls’ mean scores on these same items suggest that they believe that their parents (4.17) would rate their achievements more highly than their own self-ratings (3.91), and their beliefs about their teachers’ (3.88) and their classmates’ (3.97) ratings of their achievement.

5 Concluding words

The use of the “animal metaphor” to tap Israeli grade 4 and grade 6 students’ conceptions of and beliefs about mathematics was informative. The most common themes that emerged were that: mathematics is for smart people; the learning and teaching of mathematics and its many topics is fast-paced, and that effort/diligence and persistence are needed; people like or dislike mathematics; and that mathematics is important for humanity. The beliefs held by these young elementary students might be influenced by the meaning they attribute to mathematics. As the mathematics curriculum becomes more conceptually demanding (e.g., from grade 4 to grade 6), their views of mathematics and their own mathematical proficiency may be affected; there was evidence of this in the lower perceived mathematics achievement levels of the grade 6 students compared to the grade 4 students.

It is recognized that the students’ choices of animal might be influenced by cultural issues and/or their personal experiences and familiarity with particular animals. However, some interesting differences were noted in the views inferred from girls’ and boys’ selected animals. For example, at both grade levels, girls were more likely to indicate that mathematics was for smart people, while boys were more likely to hold negative views about mathematics. Among grade 6 students, it was girls who were more likely to identify that speed, effort, and persistence are needed to learn mathematics, and that mathematics is an important human endeavor. It seemed, overall, that girls were more sensitive than boys to the challenges confronting learners of mathematics and its relevance and importance to people.

With respect to the more traditional items used to examine students' beliefs about mathematics and their self-perceptions of their achievements, as well as the differences identified by grade level and gender, there was much consistency with previous findings in the field. Students at both grade levels (4 and 6) recognized the importance of learning mathematics, with grade 6 students believing this more strongly than the grade 4 students. All students wanted to be better at mathematics than they currently believed they were. These views reflect the importance attributed to mathematics both at school and out of school. At the same time, however, the students' expressed levels of enjoyment of mathematics were disappointingly low for students so early in their school level mathematics learning journey. Grade 6 students perceived their mathematics achievement levels to be lower than did grade 4 students; as noted above, mathematical curricular demands may have contributed to this result. Many students also expressed negative views of mathematics when explaining their choice of animal representing mathematics.

Overall, there were significant gender differences favoring boys for self-perceptions of mathematics achievement, as well as beliefs about the achievement levels that parents' and teachers' would assign them. While such differences have been reported widely for older students, they are less often reported for students in elementary school (e.g., Dentith, 2008; Leder, 1992; Preckel et al., 2008).

When the "animal metaphor" findings and the self-perception of mathematics achievement data are considered together, it would appear that the girls recognize that one has to be clever to engage in mathematics, yet they do not necessarily think of themselves as good enough to succeed. As early as grade 4, the girls may already have picked up that teachers and parents hold differential, gender-stereotyped, expectations of boys' and girls' mathematics capabilities.

The gender differences that emerged, and some of the unpromising attitudes and beliefs expressed by these young students, are worrying trends with longer term implications for the life directions of these children. More research is clearly warranted. It would be worthwhile to further investigate the self-perceptions of mathematics of boys and girls who are even younger than the participants in the study reported here in order to identify at what age gender differences begin to emerge. The low levels of enjoyment of mathematics that were found among elementary-aged students also need further investigation in order to identify possible reasons contributing to this phenomenon including, for example, ways of teaching mathematics at school, the mathematics curricula encountered, and the teaching resources used. Further use of the "animal metaphor" with students at different ages and in different countries might also highlight the efficacy of the use of metaphors to reveal beliefs about mathematics.

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