Ilkogretim Online - Elementary Education Online, 2020; 19 (2): pp. 766-781
http://ilkogretim-online.org.tr
doi:10.17051/ilkonline.2020.694148

Mathematicians in the eyes of students: An image study

Arzu Aydoğan Yenmez, *Niğde Ömer Halisdemir University,* Turkey, *aydogan.arzu@gmail.com* ORCID: 0000-0001-8595-3262
Semirhan Gökçe, *Niğde Ömer Halisdemir University,* Turkey, *semirhan@gmail.com* ORCID: 0000-0002-4752-5598

Abstract. The purpose of the study is to investigate elementary school students' images of mathematicians. The study group was composed of 1115 students attending four different schools in four cities of each of four regions in Turkey. The participants were the students attending the 5th, 6th, 7th and 8th grades of these schools. Two classes, a male classroom teacher and a female classroom teacher were selected randomly from each grade level. The students were within the age range of 12-15 years. The instrument used in this study was originally developed by Chambers (1983) (Draw a Scientist Test-DAST). According to the findings, there were mutual images of mathematicians despite small cultural differences in the regions and generally it can be said that students do not known who mathematicians are and what they do. It is anticipated that results and recommendations will shed light on integration of history of mathematics with courses, on pedagogical transformations and studies focusing on image transformation.

Keywords: Image of mathematician, elementary school students, mathematics teachers, mathematics teaching, Test-DAST

Received: 17.07.2019	Accepted: 17.12.2019	Published: 15.03.2020

INTRODUCTION

Effective mathematics teaching requires understanding what kind of assistance and studying students need for a better learning (National Council of Teachers of Mathematics-NCTM, 2000). In this context, teachers should understand mathematics which they teach in depth, consider students' developments to comprehend how they learn mathematics and choose instructional tasks and strategies which will make learning effective. Program development studies of recent years have been based on the constructivist learning approach which includes learner actively in the learning process. According to this approach, students need to understand mathematics to learn it, form mathematical assumptions and test these assumptions, be encouraged to develop reasoning skills and build on the newly acquired information actively by benefiting from their prior knowledge and experiences (NCTM, 2000; Van De Walle, Karp & Bay Williams, 2013).

There has been increasing number of discussions and research studies on images of mathematics and mathematicians in the international and national literature in recent years as well as the efficient learning and teaching strategies (Kayaarslan, 2006; Martin & Gourley-Delaney, 2014; Mert, 2004; Moreau, Mendick & Epstein, 2010; Uçar, Pişkin, Akkaş & Taşçı, 2010)). The images that people have of science and scientists are supposed to represent people's perceptions of scientists and of their respective roles in society (Medina-Jerez, Middleton & Orihuela-Rabaza, 2011). These images may affect the understanding of attitudes towards, interest in, learning of and the study of science (Emvalotis & Koutsianou, 2017). The reason of increasing number of discussions and research studies on images of mathematics is that these images may affect students' attitudes toward learning mathematics-related concepts and their positive or negative attitudes toward and relationships with mathematics (Sumpter, 2013). According to several researchers, there is a general image problem about mathematics. Images are defined as the combination of individuals' cognitive and affective gains, and it is stated that images are shaped in accordance with individuals' preliminary experiences in mind (Korkmaz, 2011). Images reflect one's cognitive and affective knowledge on a given domain and can be described with drawings, verbally or in written (Korkmaz, 2009). It is emphasized that students' mental images of mathematics depend on whether they like or dislike it and make sense of it or not. It is stated that there is a negative image of mathematics especially among societies (Howson & Kahane, 1990). This limits students' options of working in mathematics in their future careers (Jaworski, 1994). Abstract, rigid, normative and rather memorization-based nature of mathematics teaching at schools affect students' images of mathematics negatively (Picker & Berry, 2000). Images are related to cognitive and affective factors; while they are cognitively about individual's knowledge, beliefs and other cognitive representations, they are affectively about individual's attitudes and feelings. Hence, image of mathematics has been conceptualized as a mental representation formed with social experience and through school, family and environment. Images reflect cognitive schemas and involve attitudes, emotions and beliefs about mathematics and mathematics learning as well (Korkmaz, 2011; Räty, Komulainen, Skorokhodova, Kolesnikov & Hämäläinen, 2011). Uçar, Pişkin, Akkaş and Taşçı (2010) conducted a study to reveal the thoughts of elementary school students about mathematics. Analysis showed that students mostly interpret mathematics as calculations, numbers and operations. Students interpreted problem solving as solving test questions and being successful in mathematics as fast and accurate calculations. Similarly, they stated that being smart is enough for success in mathematics and mathematicians are generally non-social, lonely, introverted, silent and angry people who deal with numbers (Uçar, Pişkin, Akkaş & Taşçı, 2010). In a study conducted with 4th and 5th grade students, a significant number of the students had the opinion that mathematics was interested in numbers and that students believed that learning mathematics would improve intelligence (Kayaarslan, 2006). In a study of the 10th grade students' beliefs about the nature and teaching of mathematics, it was found that most of the students believed mathematics required logic. In addition, most of the students see mathematics as an area that needs to be learned and worth the effort (Mert, 2004).

It is stated in the studies on mathematical images that most of students cannot foresee what mathematicians do or do have certain images although they do not communicate with mathematicians (Greenwald & Thomley, 2007). In primary school years, students generally like mathematics even though they have very few knowledge on mathematics and mathematicians (National Research Council- NRC, 1989). Yet, the fact that families and societies believe that mathematical skill is not improvable but innate reinforces the development of a negative mathematical image. It is thought that mathematics' state as reflected by movies, newspapers, Internet is effective on these images (Wilson & Latterell, 2001). In addition, incorrect instructional methods and strategies based on rote learning at schools develop the belief that mathematics is independent from daily life among students.

In studies on images, mathematicians are rather described as very intelligent people who are unsuccessful at social relationships (Wilson & Latterell, 2001). Thus, students perceive mathematicians as people who do not have social skills and personal lives beyond mathematics and are obsessed with mathematics to some extent (Mendick, Epstein & Moreau, 2007; Picker & Berry, 2000; Wong, 1995). These opinions make students give up studying mathematics most of the time; however, if a person is interested in mathematics, it is regarded as a good attribute, even if such students are described as very intelligent but unsuccessful at social relationships (Henrion, 1997; Mendick, Epstein & Moreau, 2007). These stereotype opinions get stronger as students have no alternative images of mathematician even if they have the awareness (Mendick, Epstein & Moreau, 2007).

For pedagogical transformations, it is required to explore students' image of mathematics. Lim and Ernest (1999) state that identifying social image of mathematics is important, and it will contribute to the transformation and improvement of society's image of mathematics. In the light of this consideration, this study aimed to investigate secondary school students' images of mathematicians.

METHODS

This study is a descriptive study. In this study, survey research covering screening arrangements made on a small group to be used for a general judgment about a population composed of many elements was used.

Participants

The study group was composed of 1115 students attending four different secondary schools in four cities that has medium-sized population of each of four regions in Turkey. One of the cities in question is in the Central Anatolia Region where the researchers are also located; other cities were chosen as they are near this city since economy, time, etc. and in another region. These three cities are in the Mediterranean, Aegean and Southeastern Anatolia Regions. In the determination of the schools located in these cities, one of the purposive sampling methods of typical sampling method was used that the sampling unit is the school. The problem of the research problem can be summarized in the form of collecting information on this sample by identifying a typical situation from the large number of situations in the population. In this direction, the schools where the socio-cultural status of the different groups and the students with intermediate socio-cultural status were selected. Thus, the schools chosen are similar in this respect. The participants were the students attending the 5th, 6th, 7th and 8th grades of these schools. Two classes, a male classroom teacher and a female classroom teacher were selected randomly from each grade level. The students were within the age range of 12-15 years. Student papers which had no drawing on (32 data) were not subjected to review. Table 1 shows the number of all data subjected to review after the exclusion of lost data.

Table 1. *Study group by regions and grade levels*

Regions	Grade 5	Grade 6	Grade 7	Grade 8	Total
Central Anatolia	77	65	60	68	270
Southeastern Anatolia	73	62	63	71	269
Mediterranean	79	76	64	75	294
Aegean	64	59	60	67	250
Total	293	262	247	281	1083

Data Collection Instruments

The instrument used in this study was originally developed by Chambers (1983) (Draw a Scientist Test-DAST). The first part of the scale involves questions for identifying students' demographics, the second part involves drawings prepared for identifying students' images of scientists working in mathematics and open-ended questions describing the drawing (based on Chambers' test), and the last part involves questions prepared by the researchers on how students perceive mathematicians around them and on their mathematics learning. It was minded that the questions prepared by the researchers in the first part are comprehensible, focused, open ended and avoid leading. The scale was also reviewed for readability and comprehensibility by 2 experts who teach Turkish Education. The pilot application of the scale was carried out with 10 students from each of the four grade levels (40 students in total) at a school in Central Anatolia Region which was not included in the study. After the pilot application, in the schools where the scale reached the last version, two classes were chosen from each class level which was randomly selected based on the fact that a male classroom teacher and a female classroom teacher. The data were collected at the most recent intervals (2-3 days) in all schools and mathematics teachers of the classes were not in the classroom during the applications.

The participants were informed about the purpose of the study and where, how and under what conditions the data would be used in accordance with the ethical rules. The application was conducted by the researchers for approximately 45 minutes and the participants were guided during the application when necessary.

Data Analysis

The scale was subjected to the content analysis in the research. The first differentiation in student drawings was observed in whether a mathematician or mathematics teacher was drawn. If the person was drawn as he/she was teaching before the whiteboard in the classroom and the description supported this drawing, the drawing was encoded as mathematics teacher. If a scientist thinking on research or an invention at a desk was drawn along with different mathematical symbols supporting the situation and the descriptions were provided accordingly, the drawing was encoded as mathematician. If the drawings and descriptions were not clear and it could not be decided, such drawings were encoded as unclear. In order to ensure the reliability of the process, raw data obtained from the study were coded separately by two experts and inter-rater agreement was calculated as 84%. It can be said that the coding reliability is at an acceptable level due to the fact that the agreement percentage is higher than 70%. This ratio scaled up to 91% after the disagreed items had been discussed. The images and the responses given to the open-ended questions were analyzed based on the following factors in the literature: images concerning mathematician's gender, physical images, image sources and characteristics of mathematicians. Data obtained from the scale were analyzed with descriptive statistical methods (percentage and frequency). Frequencies of the data and their percentages in regard to these frequencies were calculated in such a way that they reflected the content of each item. Consequently, the numerical data are presented in charts and graphics. The students were encoded based on their location and grade level. The initials CA refers to Central Anatolia Region, SE to Southeastern Anatolia Region, ME to Mediterranean Region and AR to Aegean Region along with 5, 6, 7 and 8 based on their grade levels. For example, code "SE7-23" refers to student 23 attending the 7th grade of the school in the Southeastern Anatolia Region.

RESULTS

The first differentiation in student drawings was observed in whether a mathematician or mathematics teacher was drawn. If the person was drawn as he/she was teaching before the whiteboard in the classroom and the description supported this drawing, the drawing was encoded as mathematics teacher. If a scientist thinking on research or an invention at a desk was drawn along with different mathematical symbols supporting the situation and the descriptions were provided accordingly, the drawing was encoded as mathematician. If the drawings and descriptions were not clear and it could not be decided, such drawings were encoded as unclear. Distribution of mathematics teacher and mathematician drawings by regions and grade levels are given in Table 2.

Pearson's Chi-Square values were found to be 3.323 and 0.069 respectively in the Chi-square($\chi 2$) analyses, and no significant difference was observed in students' choices of mathematics teacher and mathematician by regions and grade levels as the significance levels were 0.344 ($p>0.05$) and 0.995 ($p>0.05$).

In Table 2, according to the frequency and percentage calculations done upon the exclusion of 34 drawings which had been encoded as "unclear", most of the students (f=865, 82.5%) drew a mathematics teacher while few of them (f=184, 17.5%) drew a mathematician in the section "draw a mathematician while working". Exemplary drawings which illustrate this differentiation are shown in Figure 1.

How the students thought of a mathematician as their mathematics teachers were also observed in their answers to the questions "What are the duties of a mathematician?" "In what circumstances do we need mathematicians?" "What do you think a mathematician can do on a given day?" Exemplary answers given to the questions can be found below in the order of questions. The students were encoded based on their location and grade level. The initials CA refers to Central Anatolia Region, SE to Southeastern Anatolia Region, ME to Mediterranean Region and AR to Aegean Region along with 5, 6, 7 and 8 based on their grade levels. For example, code "SE7-23" refers to student 23 attending the 7th grade of the school in the Southeastern Anatolia Region.

Table 2. *Distribution of mathematics teacher and mathematician drawings by regions and grade levels*

	Mathematics Teacher		Mathematician		Unclear		Total
	f	%	f	%	f	%	f
Central Anatolia							
Grade 5	63	81.8%	12	15.6%	2	2.6%	77
Grade 6	49	75.4%	15	23.1%	1	1.5%	65
Grade 7	50	83.4%	8	13.3%	2	3.3%	60
Grade 8	52	76.5%	12	17.6%	4	5.9%	68
Southeastern Anatolia							
Grade 5	61	83.6%	10	13.7%	2	2.7%	73
Grade 6	48	77.4%	12	19.4%	2	3.2%	62
Grade 7	50	79.3%	10	15.9%	3	4.8%	63
Grade 8	55	77.5%	13	18.3%	3	4.2%	71
Mediterranean							
Grade 5	65	82.3%	11	13.9%	3	3.8%	79
Grade 6	61	80.3%	13	17.1%	2	2.6%	76
Grade 7	51	79.7%	11	17.2%	2	3.1%	64
Grade 8	59	78.6%	14	18.7%	2	2.7%	75
Aegean							
Grade 5	54	84.4%	9	14.1%	1	1.5%	64
Grade 6	47	79.7%	11	18.6%	1	1.7%	59
Grade 7	48	80.0%	10	16.7%	2	3.3%	60
Grade 8	52	77.6%	13	19.4%	2	3.0%	67
Regions Total							
Grade 5	243	83.0%	42	14.3%	8	2.7%	293
Grade 6	205	78.2%	51	19.5%	6	2.3%	262
Grade 7	199	80.6%	39	15.8%	9	3.6%	247
Grade 8	218	77.6%	52	18.5%	11	3.9%	281
Grand Total	865	79.9%	184	17.0%	34	3.1%	1083

"Duties of a mathematician are to lecture, solve problems and help students." (CA6-17)

"We need mathematicians so that they can explain problems in our course books to us when we cannot solve them." (AR8-52)

"They sleep, wake up, come to school, lecture, solve problems and eat on a day." (SE7-44)

Mathematics Teacher Drawings	Mathematician Drawings

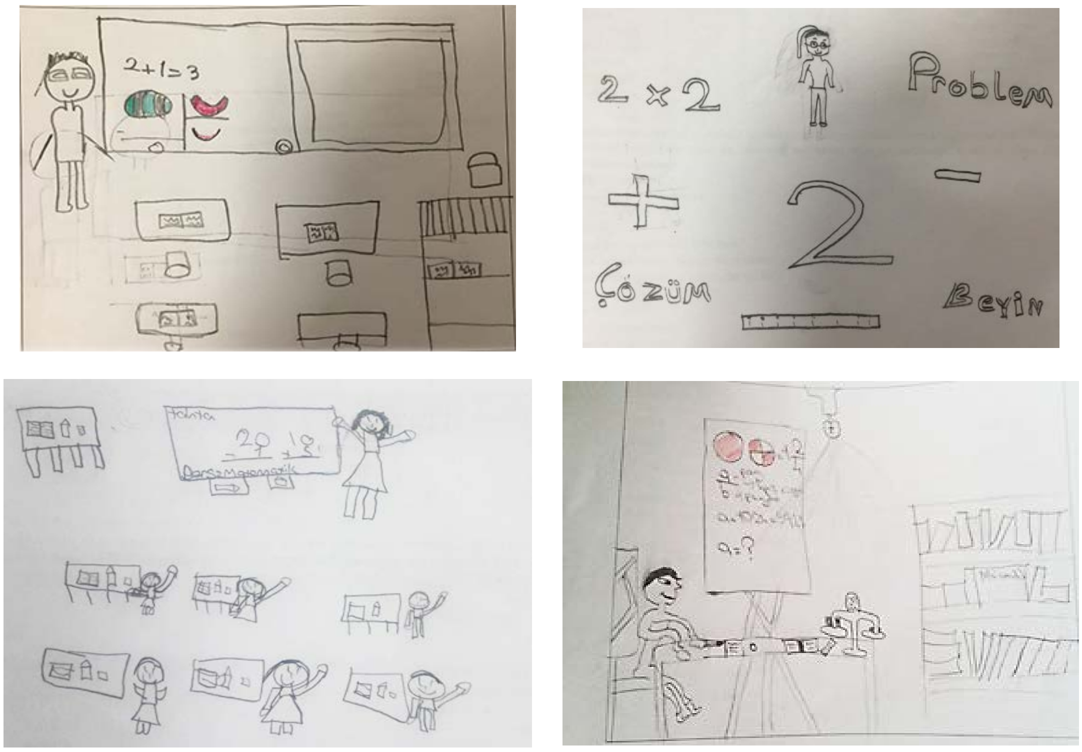


FIGURE 1. *Exemplary drawings of mathematics teacher and mathematician*

The following table shows the percentage distribution of themes exceeding 30% in the answers given to these questions. Table 3 was created with the answers provided by 978 participants. 105 students did not answer these questions. According to Table 3, the students predominantly thought of mathematicians as mathematics teachers when answering these questions.

Table 3. *Percentage distribution of themes in the answers given to the open-ended questions*

*"What are the duties of a mathematician?"**			
Lecturing/teaching mathematics	Solving problems	Holding an exam	Attending to students
87%	72%	41%	35%
*"In what circumstances do we need mathematicians?"**			
When learning mathematical subjects	For mathematical problems which we cannot solve	For calculations in everyday life	
91%	82%	49%	
*"What do you think a mathematician can do on a given day?"**			
Solves problems	Lectures	Prepares mathematical questions	Does what an ordinary person does
80%	76%	57%	43%

(*) Percentages may exceed 100% because some of the student answers were placed under multiple codes.

Table 4. *Gender distributions of students, teachers and drawings*

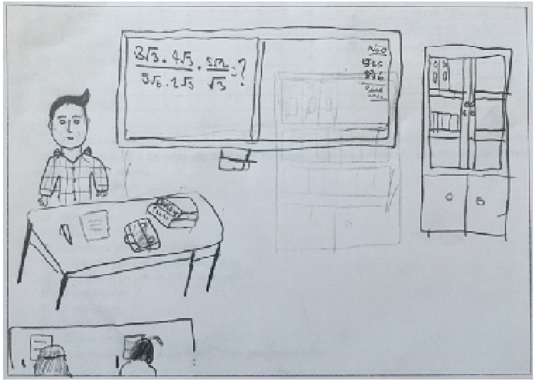
	Male Mathematics Teacher								Female Mathematics Teacher							
	Girls' Images				Boys' Images				Girls' Images				Boys' Images			
	Female Image		Male Image		Female Image		Male Image		Female Image		Male Image		Female Image		Male Image	
Region	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Central Anatolia																
Grade5	4	5.2	18	23.4	3	3.9	14	18.2	16	20.8	2	2.6	15	19.4	5	6.5
Grade6	2	3.1	14	21.5	4	6.2	13	20.0	12	18.5	3	4.6	14	21.5	3	4.6
Grade7	3	5.0	11	18.3	4	6.7	10	16.7	11	18.3	5	8.3	12	20.0	4	6.7
Grade8	2	2.9	14	20.6	3	4.4	11	16.2	13	19.1	4	5.9	14	20.6	7	10.3
Southeastern Anatolia																
Grade5	4	5.5	13	17.8	5	6.8	19	26.0	11	15.1	1	1.4	17	23.3	3	4.1
Grade6	3	4.8	10	16.1	4	6.5	13	21.0	9	14.5	3	4.8	16	25.8	4	6.5
Grade7	2	3.2	9	14.3	6	9.5	15	23.8	8	12.7	4	6.3	14	22.2	5	8.0
Grade8	1	1.4	7	9.9	2	2.8	18	25.3	9	12.7	3	4.2	22	31.0	9	12.7
Mediterranean																
Grade5	3	3.8	18	22.8	3	3.8	14	17.7	16	20.3	2	2.5	20	25.3	3	3.8
Grade6	2	2.6	15	19.7	6	7.9	17	22.4	15	19.7	6	7.9	13	17.1	2	2.6
Grade7	2	3.1	13	20.3	1	1.6	14	21.8	14	21.8	4	6.3	12	18.8	4	6.3
Grade8	7	9.4	16	21.3	0	0.0	13	17.3	12	16.0	1	1.3	17	22.7	9	12.0
Aegean																
Grade5	3	4.7	11	17.2	5	7.8	12	18.7	14	21.9	4	6.3	12	18.7	3	4.7
Grade6	6	10.2	12	20.3	4	6.8	12	20.3	12	20.4	0	0.0	11	18.6	2	3.4
Grade7	4	6.7	10	16.7	4	6.7	14	23.3	11	18.3	3	5.0	10	16.7	4	6.7
Grade8	3	4.5	16	23.9	1	1.5	10	14.9	10	14.9	5	7.5	15	22.4	7	10.4
All Regions																
Grade5	14	18.9	60	81.1	16	21.3	59	78.7	57	86.4	9	13.6	64	82.1	14	17.9
Grade6	13	20.3	51	79.7	18	24.7	55	75.3	48	80.0	12	20.0	54	83.1	11	16.9
Grade7	11	20.4	43	79.6	15	22.1	53	77.9	44	73.3	16	26.7	48	73.8	17	26.2
Grade8	13	19.7	53	80.3	6	10.3	52	89.7	44	77.2	13	22.8	68	68.0	32	32.0
Total	51	19.8	207	80.2	55	20.1	219	79.9	193	79.4	50	20.6	234	76.0	74	24.0

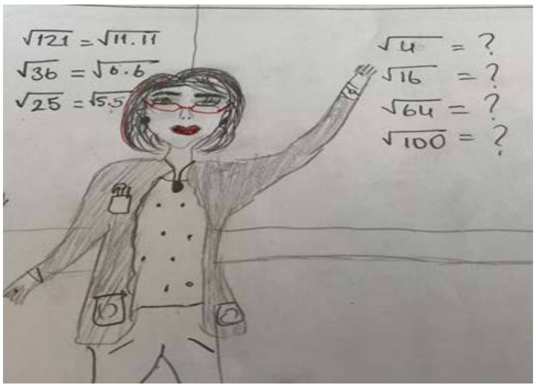
Images Concerning Mathematician's Gender

The participants were the students attending the 5th, 6th, 7th and 8th grades of a school in each of four different regions. Two classes, a male classroom teacher and a female classroom teacher were selected randomly from each grade level. Given these data, gender images of the drawings by students' and teachers' genders are presented in detail in Table 4.

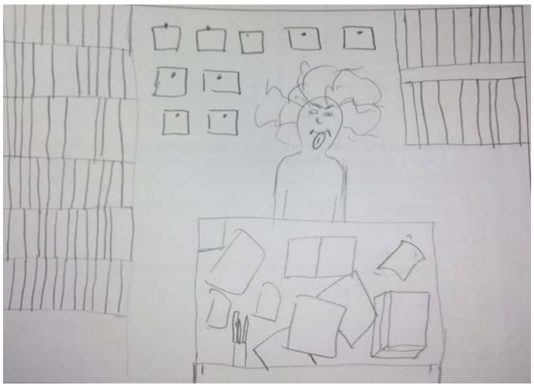
It is understood from the frequency and percentage values in Table 4 that the drawings differed by teachers' genders. Regarding the distribution of students with a male mathematics teacher, male images were illustrated at 80.2% among the girls and 79.9% among the boys while female images were illustrated at 79.4% among the girls and at 76.0% among the boys in regard to the distribution of students with a female mathematics teacher. In fact, the students wrote down the names of their own mathematic teachers in many of the drawings.

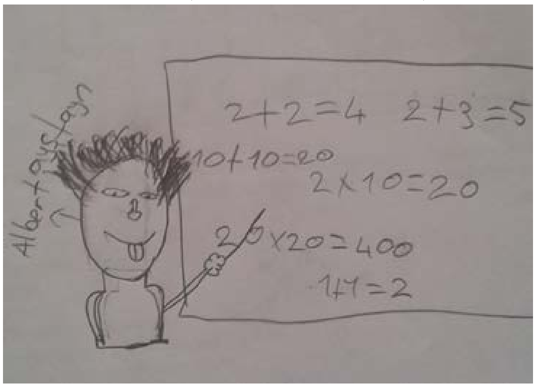
Orderly image drawings (image of mathematics teacher)



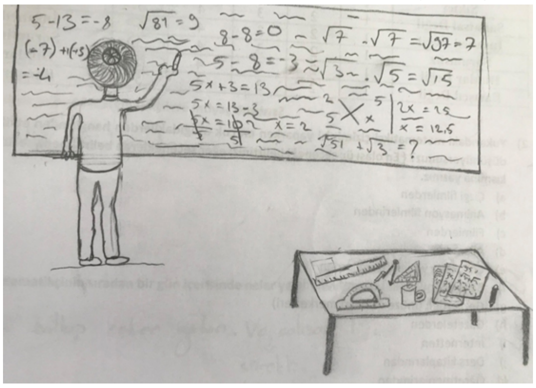


Images in which a scientist engaging in mathematics was drawn (Albert Einstein effect)





Orderly image drawings (mathematician)



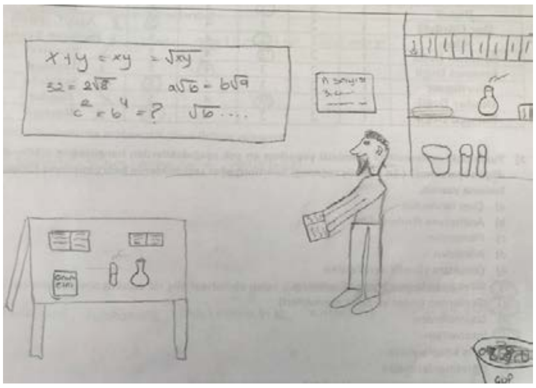
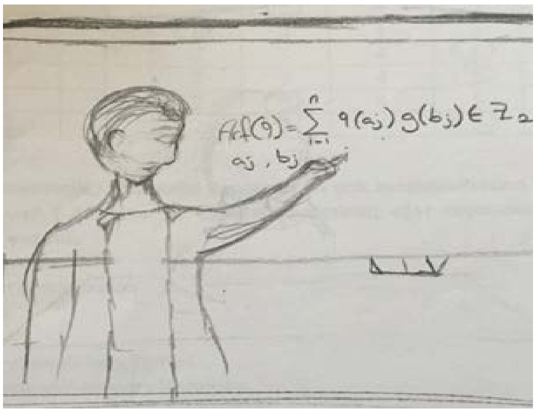


FIGURE 2. *Physical images in exemplary student drawings*

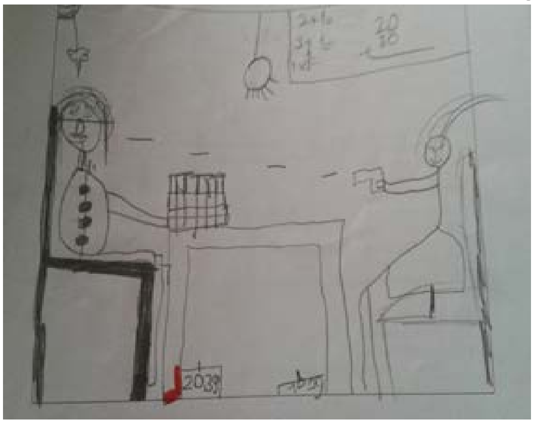
FIGURE 2 (continued)

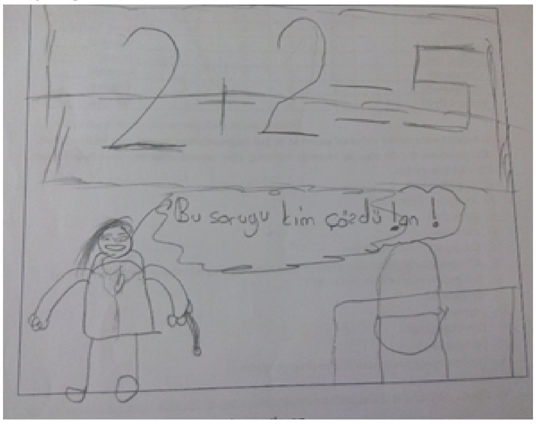
Mustafa Kemal Atatürk

Cahit Arf



Mathematic-themed images conveying hate and violence





Physical Images

This section addresses the students' images of physical characteristics of the scientists engaging in mathematics. Mutual physical characteristics were focused on when interpreting this section. In the analyses performed regardless of 34 unclear drawings, an orderly appearance (f=798, 76.1%) was dominant in the drawings of 1049 students as they drew their own mathematics teachers in general. However, in most (f=95, 51.6%) of the 184 drawings which illustrated a scientist engaging in mathematics, the students drew Albert Einstein, scientists were drawn with messy hair physically, and there was an attempt to convey the image of 'crazy professor'. They used orderly mathematicians in the remaining mathematician drawings (f=83, 45.1%). While 49 students illustrated Mustafa Kemal Atatürk, the founder of the Republic of Turkey, as a mathematics teacher and a mathematician (Atatürk wrote a Geometry terminology book), 41 students illustrated the famous mathematician Cahit Arf. A remarkable finding here is the considerable amount (f=52) of mathematics-themed drawings which conveyed hate and violence. Exemplary physical images are shown in Figure 2.

The necessity of focusing on facial expression in the images on the basis of the mathematics-themed images conveying hate and violence was taken into account, and the study also addressed the facial expression. Here, the facial expressions were categorized as negative (grumpy), neutral (indifferent) and positive (smiling). The drawings with no faces seen were not included in the analysis. If the descriptions used in the drawings with neutral facial expressions were negative, such drawings were encoded as negative facial expression. Table 5 below provides the frequency and percentage values of the facial expressions in detail.

Table 5. *Frequency and percentage distributions of facial expressions in the images*

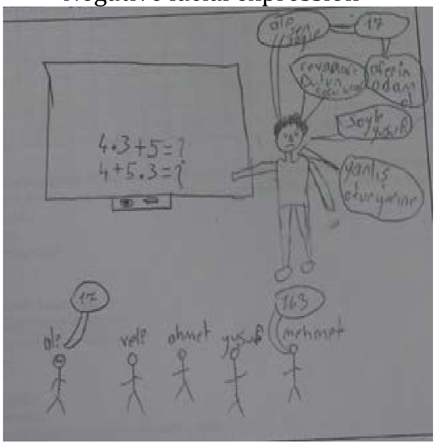
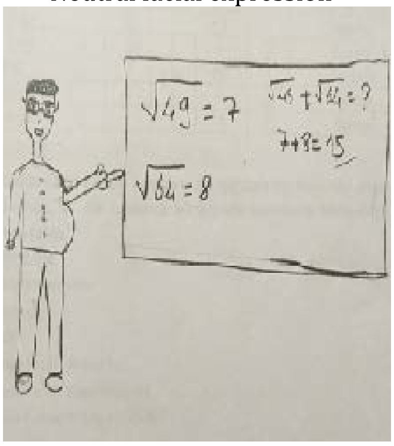
	Facial Expressions							
	Negative		Neutral		Positive		Total	Unclear
Regions	f	%	f	%	f	%	f	f
Central Anatolia								
Grade 5	15	22.7	43	65.2	8	12.1	66	11
Grade 6	19	33.3	31	54.4	7	12.3	57	8
Grade 7	16	30.2	28	52.8	9	17.0	53	7
Grade 8	19	32.2	30	50.9	10	16.9	59	9
Southeastern Anatolia								
Grade 5	16	26.7	35	58.3	9	15.0	60	13
Grade 6	15	28.8	26	50.0	11	21.2	52	10
Grade 7	18	31.6	29	50.9	10	17.5	57	6
Grade 8	17	25.0	36	52.9	15	22.1	68	3
Mediterranean								
Grade 5	22	31.4	35	50.0	13	18.6	70	9
Grade 6	20	31.3	37	57.8	7	10.9	64	12
Grade 7	19	33.3	32	56.2	6	10.5	57	7
Grade 8	18	26.1	40	58.0	11	15.9	69	6
Aegean								
Grade 5	13	23.2	34	60.7	9	16.1	56	8
Grade 6	18	35.3	23	45.1	10	19.6	51	8
Grade 7	15	27.3	30	54.5	10	18.2	55	5
Grade 8	20	31.8	36	57.1	7	11.1	63	4
All Regions								
Grade 5	66	26.2%	147	58.3%	39	15.5%	252	41
Grade 6	72	32.1%	117	52.2%	35	15.7%	224	38
Grade 7	68	30.6%	119	53.6%	35	15.8%	222	25
Grade 8	74	28.6%	142	54.8%	43	16.6%	259	22
Grand Total	280	29.2%	525	54.9%	152	15.9%	957	126

According to Table 5, there was no differentiation by regions and grade levels. The students mainly illustrated neutral (54.9%) or negative (29.2%) facial expressions. Positive facial expressions (15.9%) were observed in fewer drawings. The examples reflecting the chosen facial expression and not included in the analysis are given in Figure 3.

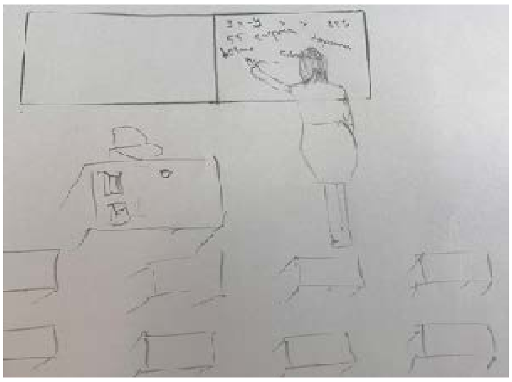
Image Sources

941 students answered the question "Which of the following did affect you most when you were drawing a mathematician in your opinion? (Mark the most possible choices; if not provided among the options, please write it down in Others section." in the research. As the students could mark multiple choices in this item, their total percentages might exceed 100%. It is understood from the answers that the students marked the choice of teacher (71.7%) and family (43.8%). Other factors marked by the students were cartoons and animation movies (13.2%) and Internet (8.7%). There were some students who wrote down their relatives who are mathematics teachers in the section Others (4.6%). For instance, "My aunt because she is a mathematics teacher" (ME6-19) and "I was affected by my uncle because he is a mathematics teacher" (AR7-38).

According to the answers given to the following open-ended question "Is mathematical skill Innate or can it be improved in time? Explain your opinions. Explain how you learned mathematics.", most of the students (79.5%) stated that mathematical skill can be improved in time. This answer was evaluated in connection with another question. As in the exemplary opinion "mathematics is improved by solving many questions and in time because the more you exercise the better you learn mathematics", the students predominantly thought that mathematics can be learned by exercising much and this can be improved in time. Despite no difference by regions, a difference was observed in the codes by grade levels. Whereas the opinion that mathematical skill can be improved in time was dominant among 5th and 6th grades (67.8% and 71.6% respectively), the answer that mathematic skill is innate was at remarkable rates (32.2% and 28.4% respectively). Like in the exemplary opinion "I cannot succeed in mathematics no matter how many problems I solve; it is all about intelligence", the students reinforced this opinion with their opinions that their effort falls insufficient before their intelligence and they cannot learn mathematics properly. This was not observed among 7th and 8th grades. The answer "mathematical skill is innate" was very low in these grades (12.1% in 7th grades and 8.5% in 8th grades).

Negative facial expression	Neutral facial expression	Positive facial expression
		

Images not included in the analysis



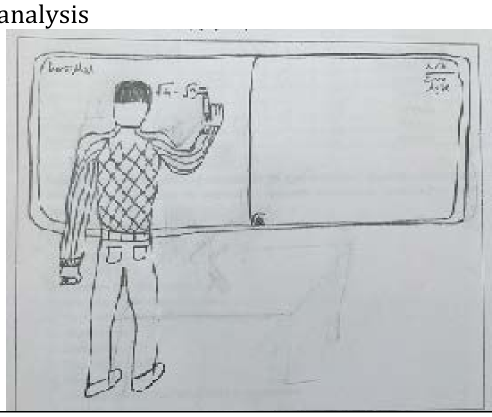


FIGURE 3. *Facial expressions in exemplary student drawings*

Characteristics of Mathematician

This section interprets a Likert-type scale and two open-ended questions together. Since 44 students did not grade some of the items, they were not included in this analysis in this section addressing the characteristics of mathematician. Figure 4 presents the box graphic of five-point Likert-type scale items.

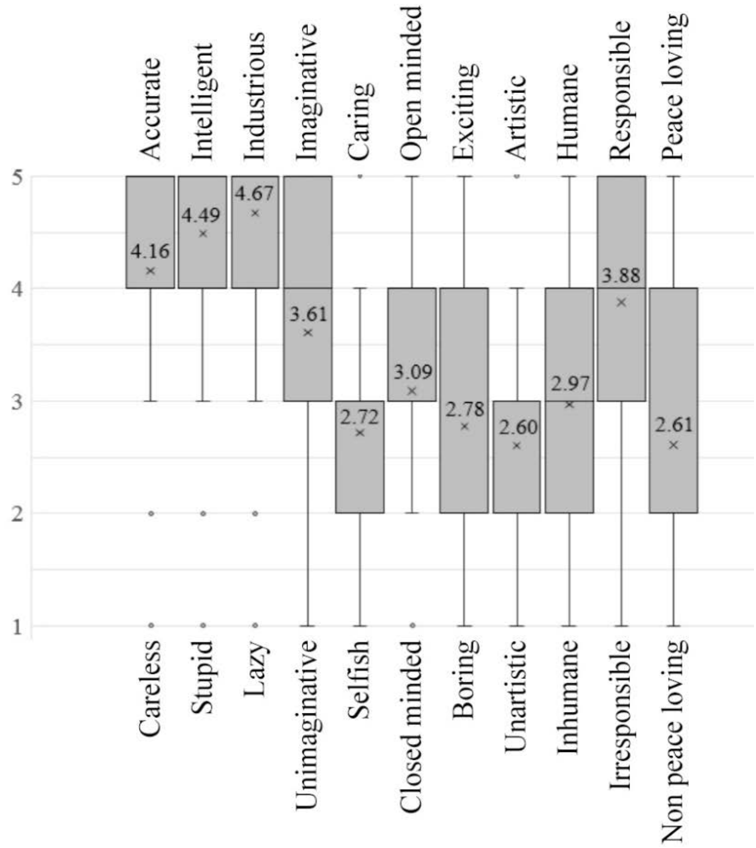


FIGURE 4. *Box plot for characteristics of mathematician five-point Likert-type scale items*

The value 3.00 does not refer to the characteristics of mathematician trending in any direction. Hence, means above 3.00 refer to positively trending characteristics of mathematician while below values refer to negatively rending characteristics. According to the mean values in the graphics, most of the students found mathematicians to be Accurate, Intelligent, Industrious, Imaginative and Responsible, they were doubtful about the characteristics Caring, Open Minded, Exciting, Artistic, Humane, and Peace loving in general, and a negative trend was observed at a small rate. Results of this scale are reinforced by the answers given to the open-ended questions "What characteristics does a mathematician have?" and "Which mathematician do you respect most? Why?" The students mostly mentioned about the characteristics Intelligent, Industrious, Accurate, and Organized in the answer to the question "What characteristics does a mathematician have?" In these analyses, codes with frequency at 50% and above were taken into consideration.

In the answers given to the question "Which mathematician do you respect most? Why?" the famous mathematicians mentioned by the students were Cahit Arf, Pythagoras, Mustafa Kemal Atatürk, Albert Einstein, Ali Kuşçu and al-Khwarizmi other than their teachers and relatives. The reasons were the fact that they were industrious and intelligent, and the reason for the answer "My Teacher" (87.3%) was primarily the humane characteristics such as loving, cheerful, friendly, humoristic and patient. This contradicts students' evaluation of their teachers in the Likert scale and their answers to this question.

DISCUSSION and CONCLUSIONS

In this study which investigated secondary school students' images of mathematician, the students described a mathematician either as a scientist or a teacher. A similar result was achieved in the study conducted by Picker and Berry (2000) on students' images of mathematicians in five countries. That study emphasize that the students could not see possible solution-focused contributions of mathematicians within everyday life problems. It is thought the reason why the students drew a mathematics teacher when they were asked to draw a mathematician while working was that they did not know what a mathematician does. The fact that people engaging in mathematics in their social lives are mainly teachers is also effective. This was also reinforced by the answers given to the open-ended questions. It is stated in various studies that there is a lack of information on what mathematicians really do and students do not know which mathematician studies in which subject of mathematics although they are engaged in mathematics starting from the preschool (Boggs, 1981; Malkevitch, 1997; Cole, 1998).

According to the findings, genders of the drawings were affected by genders of students' teachers as they mostly drew a mathematics teacher. In contradiction to the literature, the result of this research showed that gender distribution in the images was close because the number of male and female teachers was equal in the study. Drawings of a male scientist have been more common in the studies, and it is stated in the generalizations that science reflects androcentric and masculine attributes (Barman, 1999; Burton & Huber, 1995; Chambers, 1983). Similarly, male scientists were drawn in general in the study performed by Picker and Berry (2000). It has been observed in non-experimental studies investigating the images of scientists that female students have drawn more female scientists although it does represent the minority (Chambers, 1983; Song & Kim, 1999; Picker & Berry, 2000). Genders of students' mathematics teachers were dominant on the genders in the drawings because the students thought of their mathematics teachers when they were asked about mathematicians.

Indicators about physical images of scientists do not coincide with the standard indicators in previous studies (Chambers, 1983; Song & Kim, 1999; Picker & Berry, 2000; Korkmaz, 2011). In these studies, scientists were illustrated rather as messy, spectacled and wild-looking. In this study, in contrary to other studies, mathematicians were illustrated as more orderly individuals. While the students drew an image of white, middle-aged, bald or wild (messy) haired mathematician in the study of Rock and Shaw (2000), the mathematicians drawn by the students in this study had a more orderly look. The reason is considered to be that the students mainly drew mathematics teachers and reflected the image of teacher. The drawings reflected ordinary people in general. On the other hand, the students drew Albert Einstein, scientists were drawn with messy hair physically, and there was an attempt to convey the image of 'crazy professor' in most of the drawings in which a scientist engaging in mathematics. The image of “Crazy Professor” formed by the media which is standardized in several cultures might be effective in the establishment of these images. It is also thought that the reason why the founder of Republic of Turkey Mustafa Kemal Atatürk was illustrated is that his Geometry terminology book is known to the students and the reason why Cahit Arf was illustrated is that his picture is behind 10 Turkish liras. The fact that orderly, ordinary people were generally illustrated in the images is interpreted to be a positive finding because these images did not reflect the dull and unenjoyable aspect of mathematics which makes people engaging in mathematics alone and have a sleazy look unlike the studies of the relevant literature. Another remarkable finding is the mathematics-themed images which conveyed hate and violence. This finding is also reinforced by negative and neutral facial expressions in the drawings. It is accordingly thought that negative opinions, attitudes and beliefs of mathematics among the students were reflected onto the images.

In this study, the students mainly reported that their sources for the images were their teachers and families. This result has parallels with the literature. Sam (1999) stated that the most important factor that decides an individual's image of mathematics is individual's interest and to what extent he/she needs mathematics in everyday life. He presented that the next factors are family and the grade level of mathematics teacher who play an important role in family's and student's image of mathematics. He emphasized that the not only teachers but also school policies, the mathematical curriculum, other teachers and peers are effective on the image of mathematics. He stated that the last factor is the social influence by TV, movies, radio, newspaper, press, and written texts, and another influence is politicians and cultural values. Where mathematics is used in everyday life and making the need for it felt are important to the positive change in the image of mathematics. Accordingly, it is anticipated that images will be affected positively as they involve emotions, attitudes and beliefs if students' self-motivations and orientations can be achieved through teacher-parent cooperation.

Findings obtained from the answers given to the open-ended questions "Is mathematical skill Innate or can it be improved in time? Explain your opinions. Explain how you learned mathematics." are to be discussed according to the principle of psychological essentials because images involve emotions, opinions and beliefs. It was observed that most of the students thought mathematical skill can be improved in time. In parallel, Uçar, Pişkin, Akkaş and Taşçı (2010) has obtained similar results in their study. This answer was evaluated in connection with another question. The students predominantly argued that mathematics can be learned by exercising much and this can be improved in time. However, differences were observed by grade levels; although the majority thought that mathematics skill can be improved in time among the 5th and 6th grades, there were considerable number of students who gave the answer that mathematics skill is innate. Like in the exemplary opinion "I cannot succeed in mathematics no matter how many problems I solve; it is all about intelligence", the students reinforced this opinion with their opinions that their effort falls insufficient before their intelligence and they cannot learn mathematics properly. In another study, in contrast to this situation, students stated that they believe learning mathematics will improve intelligence (Kayaarslan, 2006). This was also not observed among 7th and 8th grades. Much fewer students gave the answer that mathematics skill is innate in these grades. Despite several possible reasons, it is to be handed within the context of psychological essentials. Since there is no excitement of exam in the 5th and 6th grades, teachers and parents might have tended to hold students' skill responsible in their feedbacks on lack of performance in accordance with general activity-based and problem-solving-based instructional approaches. Changing and improving appearance of mathematical skill might have been reflected by holding the lack of effort responsible for question-based studies in the 7th and 8th grades.

The prominent result concluded from the findings which was achieved in regard to the characteristics of mathematician, we can also say the characteristics of mathematics teachers as the students mainly meant their own teachers, the students did not mention about humane affective characteristics (caring, open minded, exciting, artistic, humane, peace loving) along with a negative trend at a small rate although the teachers were found to be accurate, intelligent, industrious, imaginative, responsible, and organized by the students. In addition, exemplary answers of the students "I respect a loving mathematics teacher" "I respect a mathematics teacher who does not get angry" to the relevant open-ended question emphasize the humane affective characteristics which the students expect in their mathematics teachers. This finding coincides with another finding of the study which is the predominant drawings of negative or neutral images. Given that images involve emotions, attitudes and beliefs, it presents a domain in which teachers can support students' healthy social and emotional developments. The teaching-learning process in classrooms covers all of the teacher, student and peer relationships and provides a very important environment for the teaching of social skills such as communication and respect for others. What is accordingly expected from teachers is to be able to offer a classroom setting where all students are accepted, valued and respected no matter what academic achievements they have, equal opportunities are presented for academic achievement and assistance and there are positive social relationships with adults and peers. More positive images of mathematics can be achieved by this means. Effects and roles of teachers on images and activities that they can perform can be designed in the programs for training preservice teachers.

There were mutual images of mathematicians despite small cultural differences in the regions and generally it can be said that students do not known who mathematicians are and what they do. This indicates the need for a mathematics teaching assisted with the history of mathematics. Several research studies have also emphasized the inclusion of history of mathematics in school mathematics (Fauvel & van Maanen, 2000; Katz, 2000). Courses integrated with the history of mathematics will not only introduce mathematicians but also increase students' interest in the subject and help students access more extensive information and understand the nature of mathematics and learn mathematics in a better way by enhancing their perspective of the course and use what they have learned as emphasized by Ellington (1998). History of mathematics can also show epistemological difficulties of mathematics to develop positive perspectives of mathematics by helping students see that this difficulty is by the nature of mathematics, scientists have been through this process as well and become aware of the fact that the nature of this process is difficult in the first place. Furthermore, if mathematicians can be introduced as ordinary people, the fact that students know science does not make them alone may cause them to develop positive thoughts of mathematics. This study can be carried out on the prospective teachers studying in the elementary mathematics teaching program of the faculties of education and it can be discussed comparatively in terms of the effectiveness of faculties in acquiring scientific image acquisition. At the same time, considering that images are ethno cultural values, these values in different cultures can be considered. By means of meta-analysis studies, universal image indicators and culturally related indicators were analyzed according to age, gender and so on. variables. It is anticipated that results and recommendations will shed light on integration of history of mathematics with courses, on pedagogical transformations and studies focusing on image transformation.

REFERENCES

Barman, C. R. (1999). Pupils' views about scientists and school science: Engaging K-8 teachers in a national study. *Journal of Science Teacher Education* 10(1), 43–54. doi:10.1023/A:1009424713416

Boggs, P. T. (1981). Mathematical software: how to sell mathematics, in L.A. Steen (ed.), *Mathematics Tomorrow*, *Springer-Verlag*, New York, pp. 221-236. doi:10.1007/978-1-4613-8127-3_22

Burton, G.M. & Huber, R. A. (1995). What Do Children Think Scientist Look Like? *School Science and Mathematics*, 95 (7), 371-376**.** doi :10.1111/j.1949-8594. 1995.tb15804.x

Chambers, D. W. (1983). Stereotypic Images of the Scientist: The Draw-A-Scientist Test, S*cience Education* *67*(2), 255-265. doi:10.1002/sce.3730670213

Cole, K. C. (1998). Math whizzes want respect in equation. *The Los Angeles Times,* July 14, Part A Section/Home Edition, Col.1. Retrieved December 10, 2017 from https://www.math.ksu.edu/ugrad/careerjobs/math_whizzes_want_respect_in_equation.

Ellington, R. (1998). "*The importance of incorporating the history of mathematics into the Standards 2000 draft and the overall mathematics curriculum*." EDCI 650 Reacts: History of Mathematics. University of Maryland. Retrieved November 13, 2017 from http://www.math.umd.edu/~dac/650old/ellingtonpaper.html

Emvalotis, A. & Koutsianou, A. (2017). Greek Primary School Students' Images of Scientists and Their Work: Has Anything Changed? *Research in Science & Technological Education*. Advance online publication. doi:10.1080/02635143.2017.1366899.

Fauvel, J., & Van Maanen, J. (Eds.) (2000)*. History in Mathematics Education.* The ICMI Study. Dordrecht/Boston/London: Kluwer Academic Publishers.doi: 10.1007/0-306-47220-1

Greenwald, S. J., & Thomley, J. E. (2007). Mathematically talented women in Hollywood: Fred in Angel. *PRIMUS, XVII*(1), 103-116. doi: 10.1080/10511970601126928

Henrion, C. (1997). *Women in mathematics: The addition of difference*. Indianapolis, IN: Indiana University Press.

Howson, A.G., Kahane, J.P. (1990). A Study Overview*,* in A.G. Howson and J.-P. Kahane (eds.). *The Popularization of Mathematics*, University Press, Cambridge, 1-37. doi: 10.1017/CBO9781139013512.002

Jaworski, B. (1994). Being Mathematical with in A Mathematical Community. In M. Sedlinger (ed.), *Teaching Mathematics*, Routledge / Open University, London, pp.218-231.

Katz, V. (Ed.). (2000). *Using History to Teach Mathematics: An International Perspective.* Washington, DC: The Mathematical Association of America. Kelley.

Kayaaslan, A. (2006). İlköğretim 4. ve 5. sınıf öğrencilerinin matematiğin doğası ve matematik öğretimi hakkındaki inançları. Yayınlanmamış Yüksek Lisans Tezi. Gazi Üniversitesi.

Korkmaz, H. (2009). Gender Differences in Turkish Primary Students' Images of Astronomical Scientists: A Preliminary Study with 21st Century Style. Astronomy Education Review, 8, 1-15. doi:10.3847/AER2009023

Korkmaz, H. (2011). The contribution of science stories accompanied by story mapping to students' images of biological science and scientists. *Electronic Journal of Science Education*. 15 (1), 1-41. https://files.eric.ed.gov/fulltext/ED583992.pdf

Lim, C.S. & Ernest, P. (1999). Public Images of Mathematics, *Philosophy of Mathematics Education Journal*, 11, Retrieved December 23, 2017 from http://people.exeter.ac.uk/PErnest/pome11/art6.htm.

Malkevitch, J. (1997). Discrete mathematics and public perceptions of mathematics, in J.G. Rosenstein, D.S. Franzblau and F.S. Roberts (eds.), *Discrete Mathematics in the Schools, American Mathematical Society/NCTM,* Providence, R1, pp.89-97.
Martin, L. & Gourley-Delaney, P. (2014). Students' images of mathematics. *Instructional Science*, 42(4), 595–614. Retrieved April 6, 2018 from https://www.learntechlib.org/p/167935/.
Medina-Jerez, W., Middleton, K. V., & Orihuela-Rabaza, W. (2011). Using the DAST-C to explore Colombian and Bolivian students' images of scientists. *International Journal of Science and Mathematics Education*, 9(3), 657-690. doi:10.1007/s10763-010-9218-3.
Mendick, H., Epstein, D., & Moreau, M.P. (2007). *Mathematical images and identities: Education, entertainment, social justice*. Full Research Report ESRC. Retrieved February 18, 2018 http://www.leeds.ac.uk/educol/documents/190670.pdf
Mert, Ö. (2004). High school students' beliefs about mathematics and the teaching of mathematics. Unpublished Master's Thesis. Middle East Technical University.
Moreau, M.-P., Mendick, H. & Epstein, D. (2010). Constructions of mathematicians in popular culture and learners' narratives: A study of mathematical and non-mathematical subjectivities. *Cambridge Journal of Education*, 40(1), 25–38.doi:10.1080/03057640903567013
National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics.* Reston, VA: Author.
National Research Council, Mathematical Sciences Education Board (1989). *Everbody Counts: A Report to the Nation on the Future of Mathematics Education*, National Academy Press, Washington, DC.
Picker, S. & Berry, J. (2000). Investigating pupils' images of mathematicians, *Educational Studies in Mathematics*, 43(1), 65-94.doi:10.1023/A:1017523230758
Räty, H., Komulainen, K., Skorokhodova, N., Kolesnikov, V. & Hämäläinen, A. (2011). A picture is worth a thousand words: A comparison of pupils' images of intelligence in Finnish and Russian Karelia. *Social Psychology of Education*, 14(1), 1-22. doi:10.1007/s11218-010-9137-8
Rock, D. & Shaw, J. M. (2000). Exploring children's thinking about mathematicians and their work, *Teaching Children Mathematics* 6(9), 550-555.
Sam, L. C. (1999). Public Images of Mathematics. Unpublished Doctoral Thesis. University of Exeter,U.K.
Song, J. & Kim, K. (1999). How Korean students see scientists: The images of the scientist, *International Journal of Science Education*, 21:9, 957-977. doi:10.1080/095006999290255
Sumpter, L. (2013). Themes and interplay of beliefs in mathematical reasoning. *International Journal of Science and Mathematics Education,* 11(5), 1115–1135. doi:10.1007/s10763-012-9392-6
Uçar, Z. T., Pişkin, M., Akkaş, E. N., & Taşçı, D. (2010). Elementary Students' Beliefs About Mathematics, Mathematics' Teachers and Mathematicians. *Egitim ve Bilim*, 35(155), 131.
Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2013). *Elementary and Middle School Mathematics: Teaching Developmentally* (8 ed.). New York, NY: Pearson Education.
Wilson, J. L., & Latterell, C. M. (2001). Nerds? Or nuts? Pop culture portrayals of mathematicians. *ETC: A Review of General Semantics*, *58*, 172-178.
Wong, K. Y. (1995). Images of mathematicians. In R.P. Hunting, G.E. Fitzsimons, P.C. Clarkson, & A.J. Bishop (Eds.), *Regional collaboration in mathematics education* (pp. 785-794). Melbourne: Monash University.