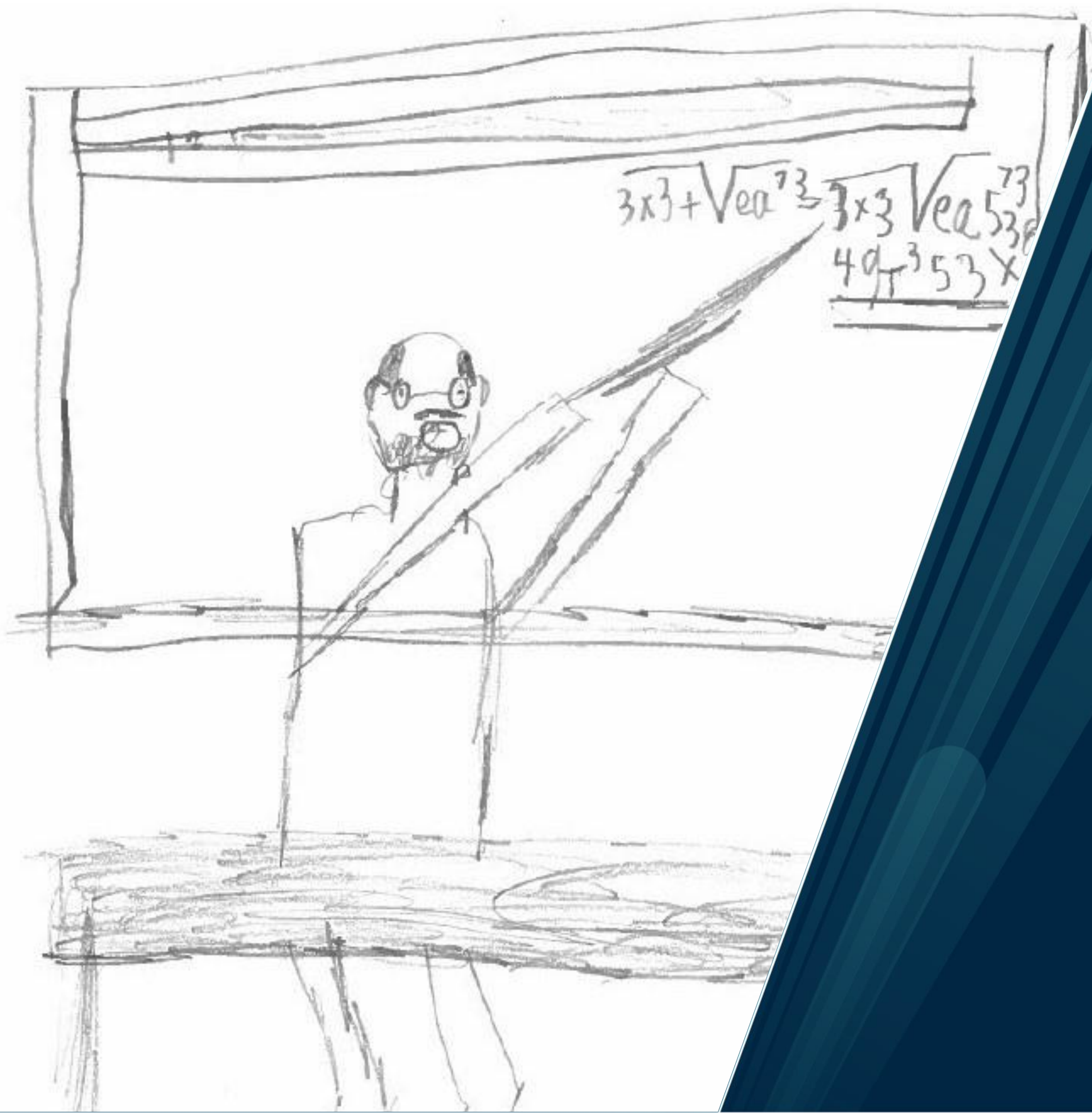
UiT The Arctic University of Norway

Department of Psychology, UiT The Arctic University of Norway

Stereotypes and Mathematics: A Quantitative Approach to the Draw a Mathematician Test.

Johanne Sofie Dalvik

Main thesis for Cand. Psychol (PSY-2901), autumn 2022, Tromsø.



Foreword

Mathematics and its image problem was pitched as a possible topic for the main thesis in psychology by Gabriella Óturai and Sarah Martiny. I found the suggestion interesting, as my attitude towards mathematics has become much more positive in adulthood, than it was in my childhood. After having an interesting conversation with a friend of mine that is a mathematician, I decided I would like to find out more about the perception we have of mathematics and mathematicians. I therefore contacted Gabriella, and together with Sarah we started developing the frame for the study in March and April of 2022.

I would like to thank Gabriella Óturai, the main supervisor and Sarah Martiny, the co-supervisor for great guidance and collaboration. I came up with a couple of possible research questions relevant to what we had discussed in earlier meetings, and my supervisors helped me to concretize them. Together we developed the method that was to be used in data collection and analysis. I recruited two schools to participate in the project, and Sarah was very helpful in recruiting the third and last school. I did the data collection at the schools following the method we had developed. The coding was done by me and Gabriella, and then discussed in a meeting with Sarah. I had good help and guidance from Sarah when analysing the data. The paper is written by me. Gabriella and Sarah have given me feedback along the way.

I would like to thank the school classes that participated in the project. All the teachers were very helpful, and the children gave the most important contribution: the data. I would also like to thank the Child Development research group at the Department of Psychology at UiT, for allowing me to present and discuss my project during group meetings and having helpful questions and inputs.

Abstract

It is important to uncover attitudes and perceptions about mathematics, especially since attitudes can play a part when students choose to, or not to continue with mathematical studies. The “Draw a mathematician test” (DAMT) has been utilized to assess the perceptions of mathematicians, but not many have addressed the connections between a negative perception of mathematicians and a negative attitude towards mathematics. Data was collected in the autumn of 2022; 54 Norwegian 5th graders completed the DAMT and a questionnaire about attitudes toward mathematics. A correlation analysis showed non-significant and small correlations between stereotypical drawings of mathematican in the DAMT and attitudes towards mathematics. To investigate what characteristics are specific for the stereotype of mathematicians we used journalists as a control profession. An ANOVA showed no significant difference between the personal characteristics of the different professionals, but there was a significant difference in the drawn surroundings between the two professions. Lastly, previous DAMT studies point to most mathematicians being drawn as men, especially when drawn by boys. An ANOVA showed that the only significant predictor for the gender of the drawn person was the gender of the child. This could indicate a change in the perception of mathematics as a male profession, and future studies should investigate if this is the case. The results of this study encourage caution with use and interpretation of the DAMT to determine stereotypical perceptions and suggest that the DAMT should not be used as a tool to measure attitudes towards mathematics.

Stereotypes and Mathematics: A Quantitative Approach to the Draw a Mathematican Test.

Mathematics is an important subject. Society depends on people who are skilled at mathematics to do certain work, like engineering, physics, economy and of course, mathematics. Mathematics is also important in almost all kinds of higher education and several vocational subjects. In addition, all people are likely to have some use of mathematics in their everyday lives, for example in managing personal economics, estimating time, or even in cooking. Although mathematics is important, it still has a bad reputation. In a study by Brown et al. (2008), 16-year-old students reported that perceived difficulty, lack of confidence, dislike, boredom, and lack of relevance were reasons for them not to continue with mathematics. In addition to mathematics being perceived as difficult and boring, it can elicit feelings of anxiety in some, resulting in math anxiety (Foley et al., 2017; Maloney & Beilock, 2012). Several people have wondered why mathematics has this bad reputation and have presented suggestions on how to combat it, all of which start during the school years with children or youths (Johnsen & Natås, 2017; Rattan et al., 2012; Yeo, 2022). Understanding children’s views of mathematics is therefore an important step towards understanding why mathematics has a bad reputation.

This study aims to explore Norwegian children's views and attitudes towards mathematics as a subject and mathematicians, using a questionnaire as an explicit measure and drawings as an implicit measure. In Norway, the role of mathematics in school has been debated. In 2015 the Norwegian ministry of education and research launched a new national strategy to strengthen children’s competence in the natural sciences (Kunnskapsdepartementet, 2015b). In the press release for the new strategy the minister of education pointed to Norwegian children's bad results in mathematics, and that a better mastery of the subject was one of the main goals of the new strategy (Kunnskapsdepartementet, 2015a). Since 2015 the mathematic competence among Norwegian pupils seems to have improved somewhat, especially for the younger grades. Norwegian 5th graders do well in mathematics, in fact in the Trends in International Mathematics and Science Study(TIMSS) from 2019 they score high on a European level (Kaarstein et al., 2020). However, math performance drops down to an average European level for Norwegian 9th graders in the TIMSS (Kaarstein et al., 2020). According to Utdanningsdirektoratet (2022), the average grade level for Norwegian 10th graders finishing primary school reflects a "good enough" to "good" understanding of mathematics (average grade is 3.8 on a scale of 1-6). The average grade has increased slightly over the past decade (Utdanningsdirektoratet, 2022). The Organization for Economic Co-operation and Development (OECD) has a program for international student assessment, also known as PISA, with 79 participating countries. The 2018 PISA shows that Norwegian 15-year-olds perform above average in mathematics in comparison with the other participating countries (Jensen, 2019).

Even though Norwegian 5th graders are seemingly good at mathematics according to the TIMSS (Kaarstein et al., 2020), they still score below average on the liking of the subject in TIMSS: Students' attitude (Mullis et al., 2020). It's a paradox that children wouldn't enjoy a subject in which they do well. This could be of particular importance as Brown et al. (2008) found that increasing enjoyment and reducing boredom might be one of the most effective ways to increase recruitment to further mathematics studies. The current study utilizes a questionnaire to explore Norwegian 5th graders' attitudes toward mathematics. As the TIMSS indicates, children might already have started to form a negative attitude towards mathematics at age 9-10 years (5th graders in Norway), and therefore this is the age group the current study will focus on.

As mentioned, the current study uses drawings as an implicit measure. Children's drawings have been used for nearly a century as an investigative tool. Goodenough (1926) utilized children's drawings to test intelligence through the "Draw-a-person-test". Since then, the "Draw-a-person-test" has also been used as a projective test both in research and in clinical settings (Koppitz, 1984; Lie, 1995). As pointed out by Koppitz (1984, pp. 1-2) drawings are a form of nonverbal communication, and therefore can be analyzed, like other communication forms. Most children also quite enjoy drawing, which makes it a particularly useful tool when working with children (Chambers, 1983; Koppitz, 1984).

The "Draw-a-person-test" has led to the development of another drawing test, the "Draw-A- Scientist-test", from now on referred to as the DAST (Chambers, 1983). The stereotypical image of a scientist was first described by Mead and Metraux (1957). The stereotypical image of a scientist, which also often appears in the DAST, is a middle-aged or elderly man with a lab coat, eyeglasses, and facial hair, surrounded by symbols of science and research. These views seem to be persistent in multiple studies (Chambers, 1983; Ferguson & Lezotte, 2020; Finson, 2002). Chambers (1983) also discovered that drawings with the stereotypic image get more frequent as children age and it can be affected by pop cultural figures.

The DAST has been adapted into a "Draw-A-Mathematician-Test", from now on referred to as the DAMT, which aims to investigate how mathematicians are perceived (Picker & Berry, 2000; Rock & Shaw, 2000). The current study uses the DAMT to investigate 5th graders' views of mathematicians. The DAMT has found several of the same stereotypes that appear in the DAST. A mathematician is often portrayed as a middle-aged or elderly man with eyeglasses and facial hair (Grevholm, 2011; Hatisaru, 2020; Picker & Berry, 2000). In addition the mathematician can be portrayed as overworked or consumed by his work in such a degree that he does not take well care of himself, or he is out of touch with the rest of the world, such as wearing outdated fashion (Grevholm, 2011; Hatisaru, 2020; Picker & Berry, 2000). Grevholm (2011) found it hard to believe that young people could identify with such stereotypic images of mathematicians as found in her study. She speculates that for them to even consider pursuing mathematics they need another image of mathematicians. One DAMT study with high achieving 16-year-old students as participants, seemed to elicit a more positive image of a mathematician as being happy and well dressed, but even in this study the mathematician was often male, and sometimes wearing glasses (Aguilar et al., 2016). The DAMT has also found a tendency to draw the mathematician as a math teacher (Hatisaru, 2019; Picker & Berry, 2000). This might be because children do not necessarily possess knowledge about what a mathematician does (Picker & Berry, 2000; Rock & Shaw, 2000). Picker and Berry (2000) also noted that there are some rather negative portrayals of mathematicians, especially math teachers, displayed with guns and other violent behavior, or using coercion. This might reflect the children’s own negative experience with learning mathematics. This same trend is not seen in the DAST.

There have been pointed out some methodical issues with the use of DAST and drawings in general. Brumovska et al. (2022) emphasize the importance of giving children the opportunity to explain their DAST drawing, to avoid interpretation errors. Reinisch et al. (2017) also point out the difficulty of interpreting symbolism in drawings without speaking with the person who drew it. Characteristics such as ethnicity and gender can also be hard to interpret without additional information from the drawer. Several of these issues can be solved with adequate follow-up questions.

The DAMT has been utilized in several countries such as Mexico, Turkey, USA, United Kingdom, Finland, Sweden, and Romania (Aguilar et al., 2016; Hatisaru, 2019, 2020; Picker & Berry, 2000). Picker and Berry (2000) did their study in five different countries, and could report only small cultural differences. In Norway, Grevholm (2011) used the DAMT with 12 students in Norwegian upper secondary school. The drawings in Grevholm’s study still display some of the stereotypical trends seen in the other studies, with the mathematician being an old or middle-aged man with eyeglasses and facial hair. Interestingly, there was only one participant that drew the mathematician as a teacher, unlike trends seen in other studies. This might be attributable to the participants being older than the participants in previous studies and having a better idea of what a mathematician does. There were also no clearly negative images, such as the more violent ones that emerged in the study by Picker and Berry (2000). Another Norwegian longitudinal study utilized a variation of the DAMT where the participants, who were university students, were asked to draw a mathematics teacher instead of a mathematician (Gjøvik et al., 2022). Interestingly the assignment of drawing a mathematics teacher did lead to a lot of the same stereotypical characteristics that are seen in the original version of DAMT, with the teacher often being male, and having characteristics such as glasses, facial hair, and hair loss appearing frequently.

Though there is research showing a stereotypical perception of mathematicians, and research indicating that some people have a bad attitude toward mathematics in general, there has been little discussion about the connection between these factors. Does a stereotypical perception of mathematicians also mean a negative attitude toward math in general or are the two unrelated? Separately both a negative attitude towards mathematics, and a stereotypic perception of a mathematician might lead to discouragement in pursuing further mathematics studies. A stereotypical image of an older and somewhat unattractive man might not make mathematics an attractive field to pursue for younger people, especially girls (Steele, 2003). A negative attitude towards mathematics can stem from the aforementioned perception of mathematics as difficult, boring, and useless (Brown et al., 2008), which in turn is likely to make further studies or career choices involving mathematics unattractive. Norwegian pupils that have low self-confidence in mathematics, low perceived value of mathematics, and low enjoyment of mathematics are more likely to choose practical mathematics instead of choosing the more advanced mathematics in upper secondary school (Opstad & Årethun, 2019). Chambers (1983) points out the possibility of interesting correlation between the DAST and other social and psychological parameters, however, he also speculates that the DAST is more useful for identifying, rather than measuring attitudes. If there is a connection between attitudes towards mathematics and a stereotypical perception of mathematicians, a negative attitude towards mathematics may also lead to a more negative or stereotypical view of the people who work with mathematics. It could also be the other way around, that a stereotypical image of mathematicians leads to an overall negative attitude towards mathematics, as mathematicians are perceived as an undesirable group to identify with, or because a stereotypic perception could be an indication of lack of knowledge. The first hypothesis (H1) is therefore that there is a correlation between negative attitudes toward mathematics and a stereotypical portrayal of a mathematician.

Most previous studies using the DAMT have been qualitative, and therefore not included any form of control. It can be difficult to judge to what extent the characteristics of drawings were specific to mathematicians, as opposed to being a result of the participants’ drawing style, or children's general perception of adults at work. The current study, therefore, includes a control profession, with a between-group design. When picking a control profession, it was considered that it shouldn't be a profession that is too familiar to the children, to make it more comparable with a mathematician, and to avoid any existing very positive or very negative associations with the profession. Stereotypic knowledge often connects professions to gender, certain professions are perceived as more masculine or more feminine than others (Reby et al., 2022; Wood et al., 2022). A study by Wood et al. (2022) where children rated a list of 22 different professions found that the only profession on the list without a clear gender stereotype was journalist. The control profession used in this study is therefore journalist, as this has no specific gender stereotype, and is not a profession that is too familiar to the children. The second hypothesis (H2) is that the stereotypical characteristics of a mathematician previously identified in the DAMT will appear more often in the 5th grader's drawings of a mathematician than in their drawings of a journalist.

There are gender differences in mathematics. Traditionally, mathematics has been viewed as a masculine subject, because more males has pursued the field at a more advanced level (Meece et al., 1982). The stereotype of men being superior in mathematics can cause women to underperform when reminded of the stereotype right before being tested, an example of a stereotype threat (Spencer et al., 1999). For Norwegian 5th graders, there is not much difference between boys and girls in mathematical skills, but boys still have significantly higher self-esteem than girls when it comes to mathematics (Kaarstein et al., 2020). Mathematics is by some considered to be more suitable for males than for females (Forgasz et al., 2014), while other studies argue that the perception of mathematics as a masculine subject is changing (Van der Vleuten et al., 2016). The PISA shows that Norwegian girls perform somewhat better than Norwegian boys in mathematics (Jensen, 2019); Kurtz-Costes et al. (2014) showed that children with a mean age of 9.5 years, had an ingroup bias towards their own gender when asked which gender they thought were most capable in mathematics. The ingroup bias disappeared when older children were asked the same questions. Older children showed a more egalitarian view of mathematics abilities, or a view in favor of girls being better at mathematics, instead of the traditional view of males being better at mathematics. If the conception of mathematics as a masculine subject is changing and is now perceived as a more gender-neutral subject, it would be interesting to see if that is reflected in perception of mathematicians as well.

In both the DAST and DAMT drawings of female scientists and mathematicians are less frequent than drawings of male scientists and mathematicians, though there are some exceptions where the mathematician is drawn as a school teacher, and therefore is more often portrayed as a female rather than male (Hatisaru, 2019). This could be because teaching is considered a more feminine profession (Kestere et al., 2013; Wood et al., 2022). Yet the trend has been that non-teacher mathematicians are drawn as males, particularly by male students (Picker & Berry, 2000). In the study by Gjøvik et al. (2022), there was a significant increase in the number of female mathematics teachers that were drawn in 2020 versus the number of female mathematics teachers drawn in 2007. Even though drawings of female mathematics teachers increased, female teachers were more likely to be associated with less advanced mathematics than male teachers (Gjøvik et al., 2022). The stereotype of a male mathematician is prevalent, and young girls are aware of this from an early age. Steele (2003) found that young girls would more often draw a male when asked to draw an adult mathematician but would more often draw a female when asked to draw a child that was good at math. Boys in the same study would more often draw a male, regardless of the age of the mathematician.

The third and last hypothesis (H3) is, therefore: The mathematician is more often portrayed as a man in the drawings than the journalist, especially when drawn by boys.

Method

Sample

The sample consisted of 54 children from three different schools in Tromsø Municipality in Norway. At the time of the data collection, all children were enrolled in 5th grade and were around 9 or 10 years old (Mean age = 9.8 years, *SD* = 0.47). The sample consisted of 20 girls, 31 boys, and three children who did not wish to state their gender. Participation was voluntary and all the participants provided written consent from their parents or legal guardians. The study was approved by Sikt- Norwegian Agency for Shared Services in Education and Research, and the Department of Psychology's internal research ethics committee (IPS-REC).

Four cases were excluded from the analysis because of too poor-quality drawings or the drawings and answers to the questions about the drawing clearly showed that the child did not understand the task instructions properly. This left us with data from 50 children to analyze, 19 girls, 28 boys, and 3 children who did not wish to state their gender.

Material

All the study material was put together in a booklet with the first page only containing the drawing instructions at the top, see Appendix 1. Half of the children were instructed to draw a mathematician at work and the other half to draw a journalist at work. On the next page, there were questions for the children to answer about their drawing to make the interpretation easier. The questions asked if the children had drawn someone they knew, and if so where they knew them from such as a family member, a teacher, someone they know from TV or movies, a famous mathematician/journalist, etc. The children also answered questions about the age and gender of the person they drew, and if the person has hair, as this has been pointed out as especially hard to interpret in previous studies (Reinisch et al., 2017). The children were also asked to write something about what the person they drew is doing in the drawing.

In the booklet, the children were asked to state their age and gender. The other task in the booklet was a questionnaire on attitudes towards mathematics containing a Likert scale ranging from “Very much agree” to “Very much disagree”, that the children were asked to fill in. The questionnaire contained the following scales: Children’s liking of mathematics, children’s confidence and self-efficacy in mathematics, and children’s perceived value of mathematics. The subscale of liking mathematics and self-efficacy each had four items, while the subscale of the perceived value of mathematics had three items. The self-efficacy subscale had questions inspired from the questionnaire used in the TIMSS (Mullis et al., 2020), but translated to Norwegian, such as “I learn things in math quickly”, it also had an item asking if their teacher said they were good at mathematics, this item was included to try and obtain a more objective measure of whether the child is good at mathematic, as there are no grades in Norwegian primary school. The subscales for liking mathematics had, among others, an item that was “I like mathematics”, and a reverse item of “mathematics is boring” that were retrieved from the TIMSS (Mullis et al., 2020). It also had one item about wanting to learn more mathematics in the future, originally retrieved from Grundmeier (2002). In the value of mathematics subscale, there were items about the importance of mathematics in everyday life, and if they would like to have a job that involves mathematics, these items were retrieved from Opstad and Årethun (2019) and the TIMSS (Mullis et al., 2020).

A reliability analysis for the subscales of the questionnaire showed high reliability for the subscale liking mathematics with α = .891. The subscale of the perceived value of mathematics had lower reliability with α = .687. The subscale of confidence and self-efficacy included a reversed item that a lot of the children struggled to understand the wording of: "Mathematics is not one of my strengths". Several children asked questions about this item during the data collection, and even more, were seemingly confused by this item, as their answers to the item were inconsistent with the rest of their answers in the questionnaire. The Cronbach's alpha also improved slightly (with .020) when the item was removed from the subscale, and because of these indicators, this item was removed from the analysis. The subscale of self-efficacy and confidence then had α = .677.

Data Collection

The data was collected between September and November of 2022. The collection took place in classrooms during school hours at the respective schools. The children in the class without written consent for participation were placed in another classroom. The researcher introduced herself and the project by letting the children know that it was a research project, and that they would get an assignment that involved drawing and answering a few questions. The children were asked to work alone and not speak to each other, but as it was a classroom setting some talk between the children still occurred. The children were told that the first assignment was to draw a journalist or a mathematician. In the first class, the children weren't sure of what a journalist and a mathematician were. They were then informed that a journalist is a person who works with news, and a mathematician is a person who works with math. To keep the instructions standardized this same explanation was given in all the other classes as well. There was no time limit for the task and there was variation in how much time each child spent on the assignment, but all of the children finished it after about 35 minutes. After everyone had handed in their drawing and questionnaire the researcher informed the class about the purpose of the study and invited the children to ask questions.

Coding

To conduct a quantitative analysis of the children's drawings they had to be quantified by coding them. Drawings from the DAST have previously been coded based on a checklist to determine the degree of stereotypicality in the drawing (Finson et al., 1995), but to my knowledge, this has not been done for the DAMT. To code the drawings, we, therefore, had to create a checklist of relevant characteristics. The characteristics to be coded were agreed upon before the data collection and were based on characteristics identified in previous studies as a stereotypical image of a mathematician (Grevholm, 2011; Hatisaru, 2019, 2020; Picker & Berry, 2000). The following characteristics were coded: body shape, body weight, gender, facial hair, glasses, facial expression, hairstyle, and well-groomed. In addition, it was coded whether the person was engaged in an activity, which included reading, writing, talking, or teaching. And whether the person used any mathematics-relevant tools, and the presence of symbols of mathematics or knowledge. The characteristics were coded as present or not present in the drawing. The variable body shape was coded as feminine, masculine, neutral, or indeterminable. Weight was coded as underweight, normal weight, overweight or indeterminable. Gender was coded as male, female, not a particular gender or other. Hairstyles were coded as long, short, bald, or indeterminable. Information about the drawn-persons gender and age was retrieved from the children's written answers in the booklet. The mathematicians were coded as teachers only when it was written by the child in the booklet, or if it was obvious from the drawing, such as pupils being present in the drawing. This rule for interpretation was also done in the study by Picker and Berry (2000).

The coding also included a list of expected items based on findings from Koppitz (1984, pp. 16-17) that these items are present on more than 85 percent of drawings by 11- and 12-year-olds. Koppitz listed 15 expected items, but three of these items were removed from our coding process. The items of two-dimensional arms and legs were removed since the children in the current study were free to draw stick figures if they wished, unlike the children in Koppitz's research. The expected item of the arms being down was also removed before coding because the children are instructed to draw a mathematician or journalist at work, which may make it more natural to also draw activities involving arms in different positions. The twelve expected items that were coded as present or not present were: head, eyes, nose, mouth, body, legs, arms, feet, hair, neck, arms at the shoulder, and two or more pieces of clothing. After coding the research team agreed to remove the expected item of "arms at the shoulder" as there was uncertainty about how to interpret this variable. The expected items score worked as an aid in judging the quality of the drawing, but no clear cut-off value was defined, as the drawing was also considered as a whole before choosing to exclude or include in the analysis.

60% of the coding was done by two independent raters and inter-rater reliability was tested by calculating Cohen's Kappa. Inter-rater reliability was high, with a kappa of .837, based on 689 decisions. The research team of three people reviewed the disagreements and agreed upon one of the coding options. This also set the guidelines for coding of the remaining 40% of the drawings.

Two drawings of journalists depicted more than one journalist. In one of them, the journalist on the left was chosen for coding as starting on the left is the general writing direction, and therefore this journalist was probably drawn first. In the other one there were three journalists present, but one of them was a bigger figure in the foreground, and this one was therefore chosen for coding.

Analysis

The data analysis was conducted using IBM SPSS Statistics 28. The first hypothesis (H1) predicted a positive correlation between negative attitudes towards mathematics and stereotypical portrayal of the mathematician. It turned out that the characteristics that we coded from the drawings included a broad range of variables. For this reason, we decided to calculate three separate sum scores to indicate the drawing's stereotypicality. First, following earlier research, we computed one general score that included all the stereotypical characteristics of the drawing. The general sum of stereotype variable had a maximum score of ten. The second score aimed at including person-centered stereotypical characteristics of the mathematician such as male gender, presence of glasses, presence of facial hair, not being well groomed, being overweight or underweight, having a negative facial expression, and hair loss. Each of the stereotypical characteristics was coded as 1 if the expected stereotype was present, and 0 if it were not present, so the maximum score for the person-centered stereotype variable was seven. This variable was expected to correlate negatively with positive attitudes toward mathematics, as these are previously identified as the stereotypic characteristics, and together make out a less attractive perception of a mathematician. The third score that was calculated focused on the surroundings of the person in the drawing and included activity, tools, and symbols. This score indicates children's knowledge about the occupation and might represent a positive attitude towards it. The surroundings variable was computed in the same way as the previous variables and had a maximum score of three. This variable was expected to have a positive relationship with a positive attitude towards mathematics, as knowledge could mean more interest in the subject. In order to test the predicted relationships, two-tailed Pearson‘s bivariate correlations were used.

The second hypothesis (H2) was that the stereotypical characteristics of a mathematician will appear more often in the drawings of mathematicians than in the drawings of journalists. This would confirm if the previously identified characteristics are stereotypic perceptions of mathematicians. To test this hypothesis, we conducted a univariate ANOVA with the general sum of stereotypes variable of the drawings as the dependent factor, and the profession of the drawn person as the independent factor. We also ran a multivariate ANOVA with the person-centered stereotype variable and the surroundings variable as well, to determine if the difference between the two professions were in the activities and the surroundings drawn, or characteristics of the person, or both.

To investigate the third hypothesis (H3) that the mathematician is displayed as a male more often than the journalist, especially when drawn by boys, a multivariate ANOVA was conducted with gender of the drawn person as the dependent variable and profession of the drawn person and gender of the child as independent variables. Our dependent variable was dichotomous. Research shows that an ANOVA used on dichotomous variables can still be robust with a big enough sample, Schmider et al. (2010) recommend having 25 participants in each condition. Lunney (1970) points to that an ANOVA can be robust with 20-40 degrees of freedom, depending on the portion of response. As the current analysis had 44 degrees of freedom, with respectively 22 and 23 participants in each group, an ANOVA should be robust enough.

Since previous studies have shown a tendency to draw mathematicians as teachers, and that this has an effect on the gender distribution of the drawn mathematicians (Hatisaru, 2019), it made sense to check if there is any gender difference between the mathematicians drawn as teachers. To investigate this, we used a Chi-Square test with the rows being the genders of the mathematicians (male or female) and the columns being teacher or not teacher.

Results

The first hypothesis (H1) was that a negative attitude towards mathematics would correlate with a more stereotypical portrayal of a mathematician. Only the drawings of the mathematicians were included in the analysis. In addition, a few participants forgot to fill out parts of the questionnaire leading them to be excluded from the analysis, therefore the $N = 24$. The three different subscales of the questionnaire correlated significantly with each other. The person-centered stereotype variable and the surroundings variable did not correlate with each other. There was no significant relationship between the mean score of the subscales self-efficacy in mathematics, the value of mathematics and liking mathematics, and the three stereotype variables, all correlations were $r < .05$, $p > .001$, $N = 24$, see Table 1.

Table 1

Means, Standard Deviation and Correlations Between Questionnaire and the Drawing

	M	*SD*	Liking math	Value math	Self-efficacy	General stereotype	Person-centred
Liking math	3.53	1.22					
Value math	3.58	0.79	.506*				
Self-efficacy	3.71	0.66	.680**	.608**			
General stereotype	2.73	1.39	.015	.022	.043		
Person-centred	1.24	1.09	-.145	-.066	.105	.849**	
Surroundings	1.44	0.97	.263	.150	-.089	.555**	.031

Note. *M* = Mean, *SD* = Standard Deviation.

* = $p < .05$, ** = $p < .001$

In order to test our second hypothesis (H2), we predicted that the mathematicians would have a higher score of stereotypicality than the journalist. Results showed in line with our prediction that the drawings of the mathematicians had a higher sum of general stereotypicality ($M = 3.32$, $SD = 1.49$, $N = 25$) than the drawings of the journalist ($M = 2.00$, $SD = 1.12$, $N = 25$). This difference was significant $F(1,49) = 12.53$, $p < .001$. The person-centered stereotypes for the drawn person were descriptively slightly higher for the mathematicians ($M = 1.28$, $SD = 1.24$, $N = 25$) than the journalist ($M = 1.08$, $SD = 0.91$, $N = 25$). This difference was however not significant $F(1,49) = 0.422$, $p = .519$. The surroundings on the drawing were on average higher for the mathematician ($M = 2.04$, $SD = 0.790$, $N = 25$)

than for the journalist (*M* = 0.84, *SD* = 0.746, *N* = 25). This difference was significant $F(1,49) = 30.51$ $p < .001$.

To test our last hypothesis (H3), namely that the mathematician would be portrayed as a male more often than the journalist, and especially when drawn by boys, we used, as mentioned, an ANOVA with profession and gender of the child as the independent variables and gender of the drawn person as the dependent variable. The drawings where the pupil had crossed the gender of the drawn person as “other” or “not a specific gender” were not included in the ANOVA. The gender distribution for the professions were nearly identical with 65.2% of the mathematicians being male, 34.8% being female and 63.6% of the journalists being male and 36.4% being female. And thus the gender distribution between professions did not differ significantly $F(1,44) = 0.12$, $p = .914$. In contrast to our hypothesis profession did not significantly predict the gender of the drawn person $F(1,44) = 2.68$, $p = .109$. The gender of the child, however, predicted the gender of the drawn person significantly, $F(1, 44) = 50.94$, $p < .001$. As can be seen in Table 2, most children drew a person of their own gender. The interaction between profession of the drawn person and gender of the child did not reach the conventional significance level, however there was a non-significant trend, $F(1, 44) = 3.51$, $p = .069$. In order to explore this trend in more detail, we conducted independent *t*-tests for boys and girls separately. Results of these *t*-test showed that girls drew more male mathematicians (*M* = 1.36, *SD* = 0.52, *N* = 11) than male journalists (*M* = 1.0, *SD* = 0.00, *N* = 7), though this difference did not reach the threshold for significance $F(1,17) = 3.56$, $p = .078$. For boys there was little difference between the gender drawn for each profession *M*s = 1.93 and 1.91, $F(1,25) = 0.049$, $p = .827$.

Table 2

Percentage of Journalists and Mathematicians Drawn as Male vs. Female by Male vs. Female Participants

	Journalists		**Mathematicians**	
	Male	Female	Male	Female
Drawn by girls	0.0	31.8	18.2	31.8
Drawn by boys	63.6	4.6	45.5	4.6

Note: Drawings in which the drawn person did not have a specified gender were excluded from this analysis. The numbers represent percentages, whereby 100% are all drawn journalists (sum of the first two columns) resp. all drawn mathematicians (sum of the last two columns).

Lastly, we did a chi-square test to test if there was a difference between how often male and female mathematicians were portrayed as teachers. There was a close to significant, but still non-significant, association between gender of the drawn mathematician and portrayal of the mathematician as a teacher $x^2(1) = 3.64$, $p = .056$. Of the female mathematicians 50% were drawn as teachers, while this was true for only 13.3% of the male mathematicians. In total, 26.1% of the mathematicians were portrayed as teachers.

Discussion

The first aim of this study was to investigate the connections between children's attitudes towards mathematics, and the degree of stereotypicality in their drawings of mathematicians using the DAMT. In addition, we wished to determine which characteristics that were specific for mathematicians, and not just a child's perception of adults at work. We did this by comparing drawings of mathematicians with the drawings of the control profession: journalist. And lastly, we were also interested in the gender aspect of children's perception of mathematicians, as mathematics has been considered as a masculine profession (Wood et al., 2022), and an majority of mathematicians in previous DAMT studies has been portrayed as male (Aguilar et al., 2016; Grevholm, 2011; Hatisaru, 2020; Picker & Berry, 2000).

Stereotypes and Attitude

The first hypothesis (H1) was that there would be a correlation between stereotypical portrayal of mathematicians and a negative attitude towards mathematics. The results of the correlation analysis did not show support for the hypothesis. None of the correlations between the stereotypes of the drawings and the attitudes measured from the questionnaire were significant. The correlations were also small, with $r < .30$ for all of them (Field, 2018, p. 117). This brings up the question of the relationship between attitudes and a stereotypical image. Nesdale and Durkin (1998) outline four possible relations between stereotypes and attitudes, "First, that group attitudes (prejudice) are an inevitable consequence of stereotypes; second, that a stereotype is simply the cognitive accompaniment of group attitude; third, that a stereotype is the cognitive component of an attitude; and fourth, that stereotypes and attitudes are independent processes that might, or might not, be consistent apparent valence" (p .220).

The results of this study seem to support the latter theory of attitudes and stereotypes being independent processes. Another possibility is that the measures used to capture the stereotypes of a mathematician weren't accurate enough. The stereotypes of a mathematican could have changed over time, or the chosen variables coded as stereotypic could be too broad or not specific enough.

The children in this sample seem to have positive attitude, or at least not overly negative attitude, towards mathematics in general. The average score for each subscale of the questionnaire leans towards the positive side of the Likert scale, as seen in Table 1. The TIMSS of 2019 showed that most of the 5^{th} graders liked learning mathematics with 39% indicating that they "somewhat like learning mathematics", and 32% indicating that they "very much like learning mathematics", compared to only 29% who "do not like learning mathematics" (Mullis et al., 2020). These numbers are, as mentioned in the introduction, below the international average for liking mathematics. The questionnaire used in this study was not identical with the questionnaire used in TIMSS, as that contained more items and was analyzed and classified differently than the questionnaire data in this study, that is mostly descriptive. It is therefore not possible to directly compare the attitudes toward mathematics in our sample with the attitudes in the 2019 TIMSS, but they don't seem to contradict each other remarkably.

Unfortunately, the correlation analysis had a small number of participants compared to the amount of collected data. This was because only half of the collected drawings, specifically the drawings of mathematicians, could be used to test this hypothesis, and because of missing data as a few participants forgot to fill out the whole questionnaire, leading them to naturally be excluded. This gives the correlations less statistical power and having a bigger sample might have made a difference. It is therefore difficult to draw a firm conclusion on the basis of these results, but it does encourage use of caution when interpreting attitudes based on the DAMT.

Journalists and Mathematicians

For the second hypothesis (H2) that the mathematician would be portrayed in line with previously identified stereotypes for a mathematician in a greater degree than the journalist, there was a significant difference for the general stereotype variable and the surroundings variable. The person-centered variable was based on seven different personal characteristics which were being male, having glasses, having facial hair, being ungroomed, being overweight or underweight, being bald and having a negative facial expression. For the surroundings certain types of activity, certain tools and presence of mathematical symbols and symbols of knowledge. It makes sense that the mathematican would in fact be portrayed as a stereotypical mathematican more than the journalist would be portrayed as a stereotypical mathematican. However, when we ran the ANOVA with the two stereotype variables of person-centered stereotype and the surroundings, only the surroundings variable was significantly different between the two professions. This means that there wasn't a significant difference between how the children portrayed the personal characteristics of the mathematican compared to the journalist. These are also the characteristics that in the first hypothesis are expected to correlate negatively with a positive attitude towards mathematics.

The age of the mathematician was not included in the stereotypicality variable and the analysis, though some previous studies point to the mathematician as being old or middle-aged as the most typical (Grevholm, 2011). The age was coded from the children's own answers in the booklet, but a lot of the children found it hard to estimate the age of the person they drew and just answered “I don’t know” or a question mark instead of writing a number. Other children wrote “old” instead of a number, and one child wrote a number containing over 60 digits when reporting the age of the person they drew. Due to several answers like these, there was a lot of missing data for the age of the drawn person. But on descriptive level, there was not a big difference between the professions, the mean age of the journalists was 32.41 years, and the mean age of the mathematicians 35.55 years.

An aim with the use of a control profession was to see if children truly portray mathematicians in a stereotypic and negative way, or if there is little difference in how they portray a mathematician at work versus other adults at work. The results point to the surroundings of the workplace, specifically the tools, activity and symbols as being the biggest difference between the two professions. It makes sense to draw mathematics symbols and tools in surroundings of the workplace as a way of emphasizing that it is a mathematican that is drawn. In the same way many children drew microphones, cameras, and news studios in the surroundings of the journalist. Reinisch et al. (2017) pointed out that when people are asked to draw a scientist, they draw not only their own conception, but also to make the scientist recognizable to others. Drawing mathematical- or journalist-relevant surroundings is a way to make the profession recognizable for others.

There was little difference in how the children portrayed the person doing the work. Most children do not have much reason to hold a negative stereotype against a journalist, as this is a relatively unknown field for them, as was evident by the questions during data collection. The fact that there is such little difference between the mathematician and the journalist points towards children not having a particularly negative stereotype regarding the personal characteristics of mathematicians either.

This study was done with a slightly younger age group than most previous DAMT studies. As mentioned earlier, there are findings from the DAST that show an increasing stereotypical portrayal of a scientist the older the children get, but by age 10-11 years the stereotypes of a scientist were close to the same level as an adult (Chambers, 1983). The children in this study were 9-10 years old, which is just a few years apart from the 12-13-year-olds in Picker and Berry's study, and around the same age as the children in Chambers study. Other research shows that by age 10 most children are very stereotype conscious (McKown & Weinstein, 2003). This indicates that if the children were to have any stereotypes towards mathematicians, it is likely to be apparent in the drawings of 9-10-year-olds.

Gender of Drawers and Drawn Person

The third hypothesis (H3) that the mathematician would be drawn as a male more often than the journalist, and especially when drawn by boys was not supported by our data. The strongest predictor for the gender of either profession was the child's own gender. Girls mostly drew female mathematicians and journalists, and boys mostly drew male mathematicians and journalists. It is astounding how equal the gender distribution between the two professions appears, with eight female journalists and eight female mathematicians, and 14 male journalists and 15 male mathematicians. Though the gender distribution of the drawn person is very similar, the sample did consist of more boys than girls. This is reflected in the fact that four girls drew male mathematicians, whereas no girl drew a male journalist.

A possible explanation to why girls drew more mathematicians of the opposite sex than boys, is that girls are simply more inclined to draw human figures of the opposite sex. After the age of eight years boys usually draw same-sex figures when asked to draw a person, but girls frequently draw opposite sex figures as well as same-sex figures (Lie, 1995, p. 51).

Even if girls are more inclined to draw opposite sex-figures it is interesting that this happened only when drawing the mathematician and not the journalist. For boys there was no difference in what profession they drew, they were more likely to draw a man regardless. This points to there still being some hold in the claim that mathematicians are in a bigger degree seen as a profession for men.

When discussing gender, it should also be noted that five of the drawn figures were indicated by children as “not having a particular gender”. Three of these were journalists, and two of them were mathematicians. They were drawn by two boys, one girl and two children who did not wish to state their gender. Although these drawings were not included in the analysis of gender differences, it is useful to take note of the fact that at least five children did not find it necessary to assign a specific gender to their drawn figure.

Another interesting finding related to gender is the distribution of drawn mathematics teachers. Half of the female mathematicians were drawn as teachers compared to only a small percentage of the male mathematicians. Three of the children who drew a female teacher also had a female mathematics teacher. This is in line with previous findings that state that when female mathematicians are drawn, they are often drawn as teachers (Hatisaru, 2019).

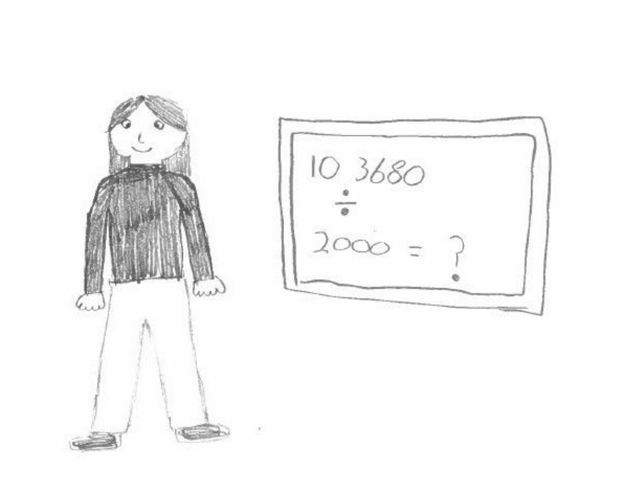
Overall, the results of this study indicate that there is diversity in the 5th graders views of mathematicians with both men and women being well represented. Mathematicians are also mostly portrayed with few negative stereotypes regarding their personal characteristics. Two drawings from the data has been selected to illustrate the range in the drawn mathematicians. Figure 1 shows the mathematican with the highest stereotypicality score, while Figure 2 shows one of the mathematican with the lowest stereotypicality score. There was no other drawing with the same stereotype score as Figure 1, it was the highest score both in the general sum of stereotype variable and in the person-centered variable. In Figure 1 we see a slender, balding man with glasses and facial hair working with complicated mathematics on a black board. There were several other drawings with the same stereotype score as Figure 2, but the selected drawing featured a female mathematician who was not drawn as a teacher. In Figure 2 we see a smiling woman who is also solving a math problem on a black board, although the mathematics here seems a lot less complicated. As mentioned earlier this was also observed in Gjøvik et al. (2022) where the female mathematics teachers often solved less advanced mathematics than the male mathematics teachers.

Figure 1

The Drawing with The Highest Stereotypical Score

Figure 2

One of The Drawings with The Lowest Stereotypical Scores



Methodical Considerations

The design of this study differed from other studies using the DAMT in that it utilized a quantitative analysis instead of a qualitative approach. This had implication for the method used in this study. For example, many other studies that has used the DAMT has had an emphasis on negative non-physical characteristics of the person drawn such as the mathematician being lonely, unsocial, overworked or unfriendly (Hatisaru, 2020; Picker & Berry, 2000; Uçar et al., 2010). These attributes are often internal qualities and usually inferred from children or youths' description of the drawing, rather than from the drawing itself. In this study we choose to focus on what could be seen in the drawing and aimed the questions afterwards so that they would be helpful in interpreting the visual attributes. This makes it difficult to determine if anyone intended to drawn a particularly lonely, unsocial or overworked mathematician.

Another aspect that has been focused on in other draw-studies is the ethnicity of the mathematician (McCarthy, 2015; Taasoobshirazi et al., 2022). This was not focused on this study, as this is often seen in the context of the drawer's own ethnicity. Due to time limitation, we did not wish to collect more demographic data from the children than necessary. In addition ethnicity has been pointed out as hard to code from drawing (Reinisch et al., 2017). This could, however, be an interesting focus for future research.

Although this study is not qualitative in its design some qualitative observations could be noted. For example, the "Einstein effect". In the study by Picker and Berry (2000) they identified seven different sub themes in pupils drawings of mathematicians, the Einstein effect being one of them, as there would always be at least one child who drew Einstein or a reference to Einstein, in each of the five countries included in their study. In our study two children explicitly said they drew Einstein. Another qualitative observation is the presence of mathematicians drawn as teachers. This often appear in DAMT studies, and this was also replicated in this study with 26% of the mathematicians being portrayed as math teachers. We used the same rules as Picker and Berry (2000) for classifying the mathematicians as a math teacher. They interpreted 21.4% of their drawings a being teachers, whilst Hatisaru (2019) had as much as 70.5% of their drawings portrayed as a math teacher. This is interesting as Picker and Berry (2000) speculate that children draw mathematicians as teacher because they lack an understanding of what a mathematician actually does. Most of the mathematicians in this study is pictured either as teaching or solving hard problems, and that seem to be the children's perception of the work of a mathematician.

There are also some methodical afterthoughts concerning the classification of some of the coding categories in this study. In order to make the checklist to code the drawings categories were made to brace several elements in the drawing, especially the categories that make up the surrounding variable all covered many different things. For example, “activity” could be teaching, reading, writing, using a black board and talking. “Tools” also included a list of possible tools used such as paper, pens, calculators, computers etc. And lastly, “symbols of math and knowledge” included both numbers and other mathematical symbols, as well as books. These categories were as mentioned earlier inspired by the DAST checklist (Finson et al., 1995). They simplified the coding process in regard to time spent and number of variables. The categories also seem to have worked out well as the surroundings variable was the one showing a significant difference between mathematicians and journalists. However, it is possible that these categories were not specific enough to be able to differentiate exactly what is unique for a mathematician. For example, many of the drawn mathematicians used a chalk board in their work. This was coded as “activity” but might have given more information as its own variable as this could indicate that many kids view using a black board as an important aspect of a mathematician’s work.

Collecting data in a classroom setting was a good option considering the timeframe for both recruitment and time spent with data collection. The classroom setting did, however, pose some challenges to the method. The classes were of different sizes, and the amount of communication between the children varied. It also seems to have affected the drawings to some degree, especially those of journalists. A teacher in one of the classes mentioned for the children that a journalist works in the newspapers, and this prompted several of the children to draw journalists sitting at their desk writing for a newspaper. In another classroom, a child asked loudly if a person that reads news on TV could be a journalist, and this seemed to have prompted several children in that class to draw a news reporter. But even in the classrooms where no one came with a loud example of the work of a journalist, the journalists was frequently drawn as news reporters or news anchors. This could be due to the prompt that "a journalist is someone who works with news" as for children the most obvious or most visible example might be someone who works on the TV news.

Some of the drawings were of rather poor quality and had a low score on the list of expected items. Even though the drawings were poor, the handwriting in the rest of the booklet was of normal quality, and it did not seem to indicate impaired motor skills or any intellectual impairment. The most likely interpretation of why some drawings were of poor quality is lack of motivation. Some children finished their drawing quite quickly, but since there was no recording of the time use for each individual drawing, it cannot be said with certainty that the ones who spent less time are the ones who produced low quality drawings, although this is a likely explanation.

Another factor that separates this study from previously done studies is the use of a control profession. Using a journalist as a control profession has given useful insight into what should truly be interpreted as stereotypical characteristics of mathematicians and what can be just a child's portrayal of an adult at work. This does bring into question how useful the DAMT is as an assessment tool. This study cannot conclude with the DAMT giving any certain information about attitudes towards mathematics, and not much information about stereotypes can be drawn from the person-centered variable either. Based on our results, the DAMT seems to be the most useful in order to investigate how children draw the workplace of different professions.

The Use of DAMT

Reinisch et al. (2017) have questioned the use of the DAST as a valid assessment tool for the conception of scientist, and advice against using it as such. An issue highlighted by

Reinisch et al. (2017) is whether the drawing is a true representation of the participant's conception of a scientist. A third of their participants reported that they could not depict their idea of a scientist in the drawing, and some contributed it to a lack of drawing skills. As briefly mentioned earlier Reinisch et al. (2017) also pointed out the issues of whether the participants drew their conception of a scientist, or drew to make the scientist recognizable to others, as this would naturally lead to a more stereotypical portrayal. Most of their participants drew both to achieve their conception and to make the image recognizable to others as a scientist. Reinisch et al. (2017) discuss the difficulty with making an adequate prompt that elicits the participant's image, without this serving as a prompt to draw something specifically not stereotypical. These could also be valid concerns with the use of the DAMT. On the other hand, Reinisch et al. (2017) did their research with adults who might have a more developed image of a stereotypical scientist than children. The DAST has proven to be a good tool to determine at what age such a stereotype emerges in children (Chambers, 1983). This has to some degree been done with the DAMT as well, by Rock and Shaw (2000), and further studies could explore whether this could be a worthwhile use of the DAMT.

Conclusion

Negative attitude towards mathematics is important to uncover as it can play a role in choosing a career, or further studies, involving mathematics. Having a negative image of mathematicians is also considered to have discouraging effect on students pursuing the field of mathematics. This study shows that 5th grade children's drawings of mathematicians are not indicative for their attitude towards mathematics. This should be considered in interpretations of the "Draw a mathematician test", as a stereotypical portrayal do not automatically mean that the drawer has a negative attitude towards mathematics.

Another reason for the DAMT to be interpreted with caution, is that personal characteristic between mathematician and the control profession journalist did not differ significantly. What is interpreted as a specific stereotype for mathematician’s are therefore limited to their surroundings in the form of activity preformed, tools used and symbols of mathematics and knowledge around them. Further studies could explore what in the surroundings that are precisely specific for mathematicians.

Children in 5th grade do not seem to perceive mathematics as an all-male profession, which lines up with findings of mathematics being considered a more gender-neutral field than before (Kurtz-Costes et al., 2014; Van der Vleuten et al., 2016). This is in contrast with previous findings in the DAMT and should be further investigated in future research.

Appendix 1

The booklet used in data collection

Instruction printed on top of the first page:

Tegn en matematiker/journalist på jobb.

Questionnaire starting on the second page:

Har du tegnet noen du kjenner? Kryss av for ja eller nei.

☐ *Ja* ☐ *Nei*

Hvis du svarte «Ja» på forrige spørsmål, hvordan kjenner du dem? Kryss av for det som stemmer best.

☐ *Fra film/TV/bok.* ☐ *En berømt matematiker/journalist.* ☐ *En lærer jeg har hatt.* ☐ *En i min familie/en slektning.* ☐ *En annen jeg kjenner.*

Har personen du tegnet et kjønn? Kryss av for det som stemmer best.

☐ *Kvinne.* ☐ *Mann.* ☐ *Personen har ikke et spesielt kjønn.* ☐ *Annet.*

Har personen du tegnet hår på hodet?

☐ *Ja* ☐ *Nei*

Hvor gammel er personen?

____

Hva gjør personen du har tegnet?

____

____

Les setningene og kryss av på det svaralternativet som stemmer best for deg

	Veldig uenig	Uenig	Vet ikke	Enig	Veldig enig
Jeg gjør det vanligvis bra i matematikk.	☐	☐	☐	☐	☐
Jeg lærer ting i matematikk fort.	☐	☐	☐	☐	☐
Min lærer sier jeg er god i matematikk.	☐	☐	☐	☐	☐
Matematikk er ikke en av mine styrker.	☐	☐	☐	☐	☐

Jeg liker å lære matematikk.	☐	☐	☐	☐	☐
Jeg lærer mange interessante ting i matematikk.	☐	☐	☐	☐	☐
Matematikk er kjedelig.	☐	☐	☐	☐	☐
Jeg ville likt å lære om vanskeligere ting i matematikk og gjøre flere ting med matte i fremtiden.	☐	☐	☐	☐	☐
Matematikk er viktig i hverdagen.	☐	☐	☐	☐	☐
Jeg vil ha en jobb som involverer matematikk.	☐	☐	☐	☐	☐

Matematikk er et veldig verdifullt og nødvendig fag.	☐	☐	☐	☐	☐

Litt om deg:

Hvor mange år er du?

____

☐ gutt ☐ jente ☐ annet ☐ ønsker ikke svare

References

Aguilar, M. S., Rosas, A., Zavaleta, J. G. M., & Romo-Vázquez, A. (2016). Exploring high-achieving students' images of mathematicians. *International Journal of Science and Mathematics Education*, *14*(3), 527-548.

Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": Attitudes of 16 year-olds towards their future participation in mathematics. *Research in mathematics education*, *10:1*, 3-18. https://doi.org/https://doi.org/10.1080/14794800801915814

Brumovska, T. J., Carroll, S., Javornicky, M., & Grenon, M. (2022). Brainy, Crazy, Supernatural, Clumsy and Normal: Five profiles of children's stereotypical and non-stereotypical perceptions of scientists in the Draw-A-Scientist-Test. *International Journal of Educational Research Open*, *3*, 100180.

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science education*, *67*(2), 255-265.

Ferguson, S. L., & Lezotte, S. M. (2020). Exploring the state of science stereotypes: Systematic review and meta‐analysis of the Draw‐A‐Scientist Checklist. *School science and mathematics*, *120*(1), 55-65.

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5 ed.). SAGE.

Finson, K. D. (2002). Drawing a scientist: What we do and do not know after fifty years of drawings. *School science and mathematics*, *102*(7), 335-345.

Finson, K. D., Beaver, J. B., & Cramond, B. L. (1995). Development and field test of a checklist for the Draw‐A‐Scientist Test. *School science and mathematics*, *95*(4), 195-205.

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. *Current Directions in Psychological Science*, *26*(1), 52-58.

Forgasz, H., Leder, G., & Tan, H. (2014). Public views on the gendering of mathematics and related careers: International comparisons. *Educational Studies in Mathematics*, *87*(3), 369-388.

Gjøvik, Ø., Kaspersen, E., & Farsani, D. (2022). Stereotypical images of male and female mathematics teachers. *Research in mathematics education*, 1-16.

Goodenough, F. L. (1926). *Measurement of intelligence by drawings*. World Book Company.

Grevholm, B. (2011). *Norwegian upper secondary school students' views of mathematics and images of mathematicians.* Current state of research on mathematical beliefs XVI. Proceedings of the MAVI-16 Conference,

Grundmeier, T. A. (2002). University students' problem posing abilities and attitudes towards mathematics. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 12*(2), 122-134.

Hatisaru, V. (2019). Lower secondary students' views about mathematicians depicted as mathematics teachers. *LUMAT*, *7*(2), 27-49.

Hatisaru, V. (2020). "[He] has impaired vision due to overworking": students' views about mathematicians. In *Theorizing and Measuring Affect in Mathematics Teaching and Learning* (pp. 89-100). Springer.

Jensen, F., Pettersen, A., Frønes, T.S., Kjærnsli, M., Rohatgi, A., Eriksen, A., Narvhus, F.K., . (2019). *PISA 2018. Norske elevers kompetanse i lesing, matematikk og naturfag.* Universitetsforlaget.

Johnsen, A. L., & Natås, E. (2017). *Hvordan fatte matte : løsningen er enklere enn du tror*. Panta.

Kestere, I., Wolhuter, C., & Lozano, R. (2013). The visual image of the teacher: a comparative study. *Acta Paedagogica Vilnensia*, *30*, 92-103.

Koppitz, E. M. (1984). *Psychological evaluation of human figure drawings by middle school pupils*. Grune & Stratton.

Kunnskapsdepartementet. (2015a). *Barn og unge skal være "tett på" realfag.* Retrived from: https://www.regjeringen.no/no/dokumentarkiv/regjeringen-solberg/aktuelt-regjeringen-solberg/kd/pressemeldinger/2015/barn-og-unge-skal-vare-tett-pa-realfag/id2435046/

Kunnskapsdepartementet. (2015b). *Tett på realfag. Nasjonal strategi for realfag i barnehagen og grunnskoleopplæring (2015-2019).* https://www.regjeringen.no/contentassets/869faa81d1d740d297776740e67e3e65/kd_realfagsstrategi.pdf

Kurtz-Costes, B., Copping, K. E., Rowley, S. J., & Kinlaw, C. R. (2014). Gender and age differences in awareness and endorsement of gender stereotypes about academic abilities. *European Journal of Psychology of education*, *29*(4), 603-618.

Kaarstein, H., Radišić, J., Lehre, A.-C. W., Nilsen, T., & Bergem, O. K. (2020). TIMSS 2019-Kortrapport.

Lie, N. (1995). *The draw-a-person test in research*. Alma mater.

Lunney, G. H. (1970). Using analysis of variance with a dichotomous dependent variable: an empirical study. *Journal of educational measurement*, *7*(4), 263-269.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in cognitive sciences*, *16*(8), 404-406.

McCarthy, D. (2015). Teacher candidates' perceptions of scientists: images and attributes. *Educational Review*, *67*(4), 389-413.

McKown, C., & Weinstein, R. S. (2003). The development and consequences of stereotype consciousness in middle childhood. *Child development*, *74*(2), 498-515.

Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students: A pilot study. *Science*, *126*(3270), 384-390.

Meece, J. L., Parsons, J. E., Kaczala, C. M., & Goff, S. B. (1982). Sex differences in math achievement: Toward a model of academic choice. *Psychological Bulletin*, *91*(2), 324.

Mullis, I. V., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). TIMSS 2019 international results in mathematics and science. *Retrieved from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls. bc. edu/timss2019/international-results*.

Nesdale, D., & Durkin, K. (1998). *Implicit and explicit processes: Stereotypes and attitudes*. L.Erlbaum.

Opstad, L. T., & Årethun, T. (2019). Choice of Courses in Mathematics at Upper-Secondary School and Attitudes towards Mathematics among Business Students. The case of Norway. *International Journal of Learning, Teaching and Educational Research*, *18 (7)*, 228-244.

Picker, S. H., & Berry, J. S. (2000). Investigating pupils' images of mathematicians. *Educational Studies in Mathematics*, *43*(1), 65-94.

Rattan, A., Good, C., & Dweck, C. S. (2012). “It's ok—Not everyone can be good at math”: Instructors with an entity theory comfort (and demotivate) students. *Journal of experimental social psychology*, *48*(3), 731-737.

Reby, D., Banerjee, R., Oakhill, J., & Garnham, A. (2022). The development of explicit occupational gender stereotypes in children: Comparing perceived gender ratios and competence beliefs. *Journal of Vocational Behavior*, *134*, 103703.

Reinisch, B., Krell, M., Hergert, S., Gogolin, S., & Krüger, D. (2017). Methodical challenges concerning the Draw-A-Scientist Test: a critical view about the assessment and evaluation of learners' conceptions of scientists. *International Journal of Science Education*, *39*(14), 1952-1975.

Rock, D., & Shaw, J. M. (2000). Exploring children's thinking about mathematicians and their work. *Teaching Children Mathematics*, *6*(9), 550-555.

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is it really robust? Reinvestigating the robustness of ANOVA against violations of the normal distribution assumption. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, *6*(4), 147.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of experimental social psychology*, *35*(1), 4-28.

Steele, J. (2003). Children's Gender Stereotypes About Math: The Role of Stereotype Stratification *Journal of applied social psychology*, *33*(12), 2587-2606.

Taasoobshirazi, G., Wagner, M., Brown, A., & Copeland, C. (2022). An Evaluation of College Students' Perceptions of Statisticians. *Journal of Statistics and Data Science Education*, 1-16.

Uçar, Z. T., Piskin, M., Akkas, E. N., & Tasci, D. (2010). Elementary students' beliefs about Mathematics, Mathematics' teachers and mathematicians. *Egitim ve Bilim*, *35*(155), 131.

Utdanningsdirektoratet. (2022, 12.09.2022). *Grunnskolekarakterer*. Utdanningsdirektoratet. https://www.udir.no/tall-og-forskning/statistikk/statistikk-grunnskole/grunnskolekarakterer/

Van der Vleuten, M., Jaspers, E., Maas, I., & Van der Lippe, T. (2016). Boys' and girls' educational choices in secondary education. The role of gender ideology. *Educational Studies*, *42*(2), 181-200.

Wood, L. A., Hutchison, J., Aitken, M., & Cunningham, S. J. (2022). Gender stereotypes in UK children and adolescents: Changing patterns of knowledge and endorsement. *British Journal of Social Psychology*, *61*(3), 768-789.

Yeo, J. B. (2022). Motivating mathematics students and cultivating the joy of learning mathematics. *The Mathematician Educator*.