The Mathematics Educator
2012, Vol. 13, No. 2, 73-84

Students' Perceptions of What Mathematicians Do

Carmen M. Latterell **Janelle L. Wilson**
University of Minnesota Duluth, United States of America

Abstract: Most secondary students are almost completely unable to describe what mathematicians do. It is unlikely that a student would desire to pursue a career of which they have no understanding. In this study, mathematics graduate students worked with 252 secondary students (Grades 10-12) for 10 hours a week for an entire school year, acting like mathematicians with the students. Post-survey shows that the students grew in their understanding of what mathematicians do. Most of them believed that they were good at mathematics, and more wanted to be a mathematician compared to before the intervention.

Keywords: Mathematicians; Perceptions; Secondary students

Introduction

When secondary students are asked to describe a mathematician, they are often at a loss (Picker & Berry, 2000; Wong, 1995). They either have stereotypical views of mathematicians (Mendick, Epstein, & Moreau, 2007; Wong, 1995) or mathematicians are completely "invisible" to secondary students (Picker & Berry, 2002, p. 50). Because students are unable to envision a mathematician, they are unable to describe what a mathematician does (Picker & Berry, 2001). This study investigated students' perceptions of what mathematicians do, and whether their perceptions can be altered. We start with a working definition of what mathematicians do.

A Working Definition: What Do Mathematicians Do?

The authors emailed a list-serve of post-secondary mathematics professors about what they do as mathematicians. Twenty-five responses were received. There was agreement that a mathematician *creates* mathematics. Here are two sample responses:

- A mathematician creates mathematics. This can mean creating new mathematical theorems and results, or applying other people's results to applied problems for practical use.
- The statement, "I am a mathematician," is similar to the statement, "I am an artist." Bound up in that statement is the statement, "I create art." Mathematicians create mathematics.

A mathematician creates new mathematics by doing such activities as: gathering data, making guesses, asking questions, conjecturing, investigating, analyzing, calculating, evaluating, reasoning, creating proofs, and looking for patterns. Applied mathematicians also create new mathematics when they create mathematical methods and mathematical models in the process of working on practical problems. Solutions to problems and the process of problem solving can also be new mathematics, just as the formulation and proof of a new theorem in pure mathematics is new mathematics.

Related Research

Most K-12 students do not have an inclination what a mathematician does (Picker & Berry, 2000). They do not come in contact with mathematicians, and yet, they form certain images of mathematicians (Greenwald & Thomley, 2007; Wong, 1995). Popular culture, such as movies, portrays mathematicians as either insane or complete nerds (Wilson & Latterell, 2001). In turn, students perceive mathematicians as mentally ill, nerdy, geeky, having no social skills, and obsessed with mathematics to the point of having no personal life beyond mathematics (Howson & Kahane, 1990; Mendick, Epstein, & Moreau, 2007; Picker & Berry, 2000; Wong, 1995). Students see mathematicians as "white, male, middle-classed, and old" (Mendick, Epstein, & Morequ, 2007, p. 19) and extremely smart (Oakes, 1990). These views most often discourage students from studying mathematics, although, if one does pursue mathematics, those students are likely to consider the nerdiness as a good feature (Henrion, 1997; Howson & Kahane, 1990; Latterell, 2005a; Mendick, Epstein, & Moreau, 2007). Even when students are aware they are reinforcing stereotypes, they are still influenced by them, most likely due to a lack of an alternative representation of mathematicians (Mendick, Epstein, & Moreau, 2007).

This results in students in the United States seeing mathematicians as "other" than themselves. For social reasons, one should not be "seen" doing mathematics (Andreescu, Gallian, Kane, & Mertz, 2008; Latterell, 2005b). Other research suggests that at the very least, it is not a social stigma to be unable to do

mathematics, as it is a social stigma to be illiterate (Latterell, 2005b).

Besides this view of mathematicians as "other," students seem to lack an understanding of what mathematicians actually do (Emmer, 1990), with much of what mathematicians actually do seeming to be "invisible" to students (Picker & Berry, 2002, p. 50). As Hammond (1978) stated, "Mathematicians are not a rare breed, simply an invisible one" (p. 15). Students "show a general lack of awareness about what mathematicians actually spend their time engaged in doing, confusing it with other professions which appear to require computation and/or measurement" (Picker & Berry, 2000, p. 73). Stetz (2002) quipped that "mathematicians are not listed in the yellow pages," meaning that while one might have reason to call a doctor or a plumber, one probably does not call up a mathematician.

When 201 seventh-graders (enrolled in seven different public schools in the Eastern part of the United States) were asked what mathematicians do, 28% said that mathematicians are teachers, 13% that they perform accounting, 12% that they fill jobs in architecture and building, 6% that they solve hard problems, and the remaining 41% left the item blank (Picker & Berry, 2001). Another study found that "children tend to think that mathematicians do the same kind of mathematics that they themselves do in the classroom" (Rock & Shaw, 2000, p. 551). Students do not view being a mathematician as an occupation (Howson & Kahane, 1990).

Picker and Berry (2002) found that sending real mathematicians into classrooms to have a one-class period panel discussion with students was enough to change their perceptions of mathematicians from a stereotype to a more realistic image. It did not, however, increase their understanding of what mathematicians do. The current study hopes to increase students' understanding of what mathematicians do. The possible implication for this is to increase their level of interest in mathematics.

Theoretical Categories

We hypothesized that popular culture (e.g., television, movies, novels), peer pressure (e.g., it is not socially acceptable to be interested in mathematics), the "invisibility" of mathematicians (e.g., one does not just call up a mathematician as one does a plumber), and the general lack of role models (e.g., students do not know many/any mathematicians, and teachers do not act like mathematicians) have led to little understanding, or even a *mis*understanding, of what a mathematician is and does. This contributes to a lack of desire of secondary students to become mathematicians, which leads to a shortage of mathematicians in the United States.

This article examines a piece of this phenomenon, and asks the question of secondary students, what do mathematicians do?

For simplicity, the authors will classify mathematicians into two types: applied and pure. Applied mathematicians use mathematical principles (both modeling and computational) to solve practical problems. Pure mathematicians use mathematical principles to advance mathematical knowledge (e.g., developing new theorems, concepts, relationships). Both types of mathematicians exhibit a set of behaviors (such as looking at patterns, analyzing data, conjecturing), but we do not suppose that secondary students will be able to describe a mathematician in such detail. We would like to think of mathematics teachers and professors (whether they are actively researching or not) as mathematicians, but we acknowledge that they often neither create mathematics nor solve applied problems. Thus, despite our desire, we do not consider mathematics teachers to be mathematicians, and only consider mathematics professors to be mathematicians if they are research mathematicians.

Finally, in examining what mathematicians do, one has to examine the related question: What is mathematics? Some students might think that mathematics is nothing more than a school subject. If so, this may lead to an inability to describe a mathematician. While there is no one correct definition of mathematics, a definition of mathematics that refers only to contents (algebra, number, space) and not processes (reasoning, abstract thinking, symbolically representing) is incomplete.

Research Questions

The three research questions are: with the inclusion of a model of a mathematician in secondary classrooms,

1. do students have a better concept of what mathematicians do?
2. do students want to become mathematicians?
3. what is the relation between wanting to become a mathematician and the perception of how good one is in mathematics?

Method

To answer the questions, we examined secondary students' perceptions before and after placing two male mathematics graduate students into eight secondary mathematics classes (each graduate student was assigned four classes) for ten hours a week for an entire school year from September 2009 to June 2010. A total of 252 students from Grades 10-12 were involved with a 60: 40 girl to boy ratio.

The graduate students brought to the classes their own graduate-level research practices and created mathematics inquiry lessons appropriate for the grade level of their students. In one class, the graduate student let the students use graphing calculators to find polynomial regression models for two area bridges. On another occasion, the students created scatterplots and found regression equations for a space shuttle mass versus time and altitude versus time, using data collected during the first two minutes of an actual shuttle launch that occurred in the United States in 2006. In a third example, the graduate student asked the students to work out how to divide up a piece of land in order to determine how much land other people own. They had to think of ways to accurately measure how much land belonged to each person. In the area of pure mathematics, the graduate students set up inquiry activities in which students were to analyze the properties of two- and three-dimensional objects and then establish the validity of geometric conjectures using deduction. Other lessons led students to discover the Fundamental Theorem of Arithmetic and the Law of Large Numbers.

The graduate students also worked with their classes on problem solving techniques, conjecturing, and proving, as well as bringing in problems on which applied mathematicians have worked. The problems were often scaled down versions of what the graduate students were actually doing on their dissertation work, and they explicitly explained this to the class. They also explained that mathematicians are employed in similar kinds of jobs.

The students were asked to answer the following questions, adapted from Rock and Shaw (2000), at the beginning and end of their school year:

1. Please describe what a mathematician does. Give as many details as you can.
2. Would you ever want to become a mathematician? Are you good at mathematics?

They were given 15 minutes to write down their answers.

To analyze the data, the first author took the completed pre-surveys and separated the responses into various categories through the process of constant comparison. A particular response may belong to more than one category. However, it turned out that every response in the pre-survey ended up in only one category, but some responses in the post-survey were classified into more than one category. After the categories were formed, they were described by suitable labels. The same process was executed with the post-surveys. The second author independently coded the responses. There was a high degree of inter-coder reliability (99%). At this point, through discussion between the two authors, two subcategories were formed. All responses for which there were disagreements between the two authors were discussed, until all coding was in total agreement.

What Mathematicians Do: Emergent Categories and Quantitative Results

Table 1 gives the percents of students who gave answers in each category by the pre- and post-survey.

Table 1
*Pre- Post survey percents: Please describe what a mathematician does (*n *= 252)*

Main Categories	Sub-categories	Pre	Post
Mathematics is a subject in school.	• A mathematician studies mathematics.	45%	8%
A mathematician solves mathematics problems.	• A mathematician works mathematics problems.	26%	38%
	• A mathematician works problems that have real-life application.	0%	38%
A mathematician creates new mathematics.	• A mathematician creates mathematics.	1%	11%
No or little concept	• A mathematician is really smart.	18%	0%
	• Left the answer blank or wrote, "I don't know."	7%	0%
	• Other	3%	2%
	• A mathematician teaches mathematics.	0%	8%

Pre-Survey Categories

Four main categories emerged during the first attempt at the pre-survey sorting. The "Other" category was for responses that did not have anything in common with any other responses, perhaps because the student was not sincere in his/her attempt at a response. The majority of students thought that mathematicians study mathematics or work mathematics problems.

Post-Survey Categories

The same four main categories emerged from the post-survey, and a new subcategory of "A mathematician teaches mathematics" was formed. This new category could be the result of seeing the graduate students as mathematicians but also doing some teaching; about 8% of the students believed so.

A subcategory was created for the "A mathematician works/solves mathematics problems" category. Many students indicated that there was a purpose to solving mathematics problems, in particular, real-world applications.

The students changed in their responses from the pre- to the post-survey. Significantly fewer secondary students thought that mathematicians sit around and study mathematics. Many students gave considerably more detailed examples of the type of mathematics problems that a mathematician might do, all in the category of applied mathematics. Another 11% gave examples that would fall in a category of creating mathematics. They wrote statements like mathematicians "spend their time understanding the principles of mathematics and discovering new ones," "try to discover new mathematical concepts," and "invent new and harder theorems." One noted: "Mathematicians use a lot of math to solve all sorts of problems. Also they try to invent new kinds of math which sometimes really has no purpose or value."

Only 5% of the secondary students described a male mathematician with the rest using terms like "a person" without specifying gender. Despite having worked with male graduate students, these secondary students did not seem to hold the common perception that mathematics is a male domain, which might be due to the fact that several of the mathematics teachers at the schools were female.

What Mathematicians Do: Qualitative Results

A Mathematician Studies Mathematics

Responses in this category suggest that mathematicians continue to learn about mathematics that has already been discovered, including learning more and harder mathematics through the years. A typical quote is that mathematicians "spend their days learning more and more about math and studying it all the time." This category did not include answers that mention activities such as proving theorems, inventing new mathematics, or applications of any kind. Although it is certainly true that mathematicians study mathematics, mathematicians do more than learn about mathematics discovered by others. However, some students may view mathematics as nothing but a subject in school, thus, mathematicians have no role other than to continue to study mathematics.

In the pre-survey, 45% of the students thought that mathematicians study mathematics, but this percent went down to 6% in the post-survey. Some students responding in this category did not seem to understand that mathematics is a subject broader than high school mathematics. They thought that it is just "harder," for instance, move from "1 + 1 = 2 to much harder calculations". Another student admitted, "There are probably specifics that I don't know of."

A Mathematician Works Mathematics Problems

The most common response in this category during the pre-survey was: "A

mathematician does math." The response "does mathematics" appears to be mostly a non-response, due to the lack of details. One might even conjure up an image of a mathematician sitting in a room working the exercises found in successively more difficult textbooks. In the post-survey, more details were provided on the mathematics problems that a mathematician might solve. Examples were given of situations that a mathematician might try to model, including possible functions that could be used in these models, such as $f(x) = 5e^x$, as a possible model of population growth.

Other examples were more general, such as how mathematicians may improve life by coming up with solutions to problems through the use of mathematics. These responses were about applied mathematicians, even though the students were unable to come up with details on how an applied mathematician does his or her job. Thus, we divided this category into two:

- A mathematician works mathematics problems.
- A mathematician works problems that have real-life application.

Most of the answers about mathematicians "work/do math" did not give any more details than that. One wrote, "mathematicians wake up. math… eat… math… sleep." Others attempted to illustrate the situation with specific problems, for instance, they solve things like "$x = 7n + 3^2 \times 8$ and $E = mc^2$" and these problems were "ones that everyday people cannot figure out," "percents," "equations," or "big scale problems".
Most of the responses in the "problems have a real-life application" category gave an example, such as building bridges, surveying lands, space travel, government problems (including working for the secret service), working for banks, working for technology companies, and helping architects.

A Mathematician Creates Mathematics
The responses in this category must at least imply that mathematicians do something beyond study already discovered mathematics and/or go beyond stating that a mathematician does mathematics. Words used by the students included *new, invent, discover, create, conjecture, prove,* and *easier*. Some examples follow:

- Finds new ways to solve hard and complicated equations.
- They discover more ways that math can be worked out.
- A mathematician is a problem-solver. They look for patterns and new ways to solve problems. They work well with numbers and are able to apply them to all sorts of situations.
- Mathematicians come up with easier ways to do things.

No or Little Concept

Responses in this category may have ignored the directions that asked for a description of what a mathematician does, and instead described attributes of a mathematician rather than actual behaviors. The descriptions focused on the extreme intelligence of mathematicians, mathematicians as mathematics teachers, or just a non-response.

Responses about the intelligence of mathematicians leave one with an image of a mathematician sitting around being very smart! Most of the students who thought that mathematicians were smart, viewed themselves, in contrast, as not so smart. Thus, we start to see this view of mathematician as "other". Some quotes follow.

- A mathematician is either a man or woman, with an abnormally large brain.
- A person who is crazy good at math. Like amazingly smart.
- A smart person who can figure out large sums to a problem mentally.

The other subcategory about mathematicians teaching mathematics includes examples such as, "Mathematicians teach math. An advance[d] mathematician may teach college math" and "Math teachers, algebra teachers, geometry teachers, calculus teachers, etc."

In the pre-survey, a small percent (7%) of the students did not give any answer or wrote they did not know. Odd responses, perhaps insincere ones, include: "there is no such thing as a mathematician"; "Mathematicians ponder the meaning of life"; "a man or woman who likes math and does not like sunlight"; and "kind of geeky person who can do cool things with fractals and pretty colors".

Wanting to be a Mathematician and Being Good in Mathematics

This section attempts to answer the second research question about whether the students wanted to be mathematicians and whether they thought they were good in mathematics. Table 2 shows the percents of students who responded to desire to become a mathematician versus their perceived ability in mathematics.

Table 2
Desire to become a Mathematician versus good at it (n = 252)

		Wants to be a mathematician	**Does not want to be a mathematician**
Is good in mathematics	Pre	18	56
	Post	33	48
Is not good in mathematics	Pre	2	24
	Post	1	18

Pre-Survey

Only 20% wanted to be a mathematician and most of them felt they were good in mathematics. Three of them thought that mathematicians make much money and another three commented that people would think they (as mathematicians) are smart. One student would like to work with other mathematicians: "I like working with other people who like math to solve challenging/long problems!"

The other 80% did not want to be a mathematician even though about two thirds of them thought they were good in mathematics. Their reasons include: they really did not know what a mathematician does; they wanted careers that work with people or did other things than just mathematics; mathematicians work too hard and their entire life is mathematics.

Post-Survey

There was a substantial increase in the number of students who wanted to become mathematicians, and virtually all of them thought they were good in mathematics and found it fun and interesting with only one mentioning the pay: "the pay that professionals in the field of math [receive] intrigues me." Those who did not want to be mathematicians wrote that they wanted to work with more than just mathematics, found it too difficult or tedious, or preferred to work with problems with more than one answer. One of them wrote: "Physicist maybe, but not a pure mathematician. I like working with more than pure numbers." Perhaps, this person was not aware of the field of applied mathematics.

Limitations and Extensions

Students' claims about being good or not in mathematics may be underestimates or overestimates. Some of them may not want to "admit" to being good in mathematics, for example, "I can understand and apply it easily. But *I like to think* [emphasis added] I'm not great at it. Just OK." Interviews may be conducted to probe deeper into this.

It is possible that the findings of this study are a feature of the American culture. It would be an interesting extension to compare results from students in other countries, especially those in which mathematics is more valued or whose students have higher mathematical ability. However, many of the researchers referenced above are not from the United States (e.g., Emmer, 1990), and the results reported here are not in disagreement with their findings.

Conclusion

The sample in this study began with very low percentage of students being able to give accurate descriptions of what mathematicians do but ended with considerably higher percentage after they had been taught by graduate students over a year. More of them thought they were good in mathematics and wanted to be mathematicians than before (from 20% to 34%). Even though this percent still remains well under half of the students, there is evidence that if one knows more about what mathematicians do, one might be more interested in becoming a mathematician.

The experiment has moved students into a deeper understanding of what it means to be an applied mathematician, from some vague sense that mathematicians work mathematical problems to a sense that they use mathematics to solve practical problems. These students have the least experience with creating new mathematics, although contact with the mathematics graduate students did increase their understanding that mathematicians create mathematics.

It is certainly not realistic to place graduate students into all secondary classrooms for 10 hours a week for an entire school year. Other ways to bring about similar positive changes may be tried. For example, the graduate students may visit schools several times a year. Another approach is to work through future teachers in teacher education programs to increase their understandings of what mathematicians do, such as mathematicians working with them, having future teachers do their own research in mathematics, or they becoming "resident mathematicians" in schools. This study at least implies that secondary students can come to understand what mathematicians do, and becoming a mathematician may be a more appealing career once they do understand what this entails.

References

Andreescu, T., Gallian, J. A., Kane, J, M., & Mertz, J. E. (2008). Cross-cultural analysis of students with exceptional talent in mathematical problem solving. *Notices of the AMS, 55*(10), 1248-1260.

Emmer, M. (1990). Mathematics and the media. In A. G. Howson & J. P. Kahane (Eds.), *The popularization of mathematics* (pp. 89-102). Cambridge: Cambridge University Press.

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

Hammond, A. L. (1978). Mathematics: Our invisible culture. In L. A. Steen (Ed.), *Mathematics today: Twelve informal essays* (pp. 15-34). New York: Vintage

Books.

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 & J. P. Kahane (Eds.), *The popularization of mathematics* (pp. 1-37). Cambridge: Cambridge University Press.

Latterell, C. M. (2005a). How we see ourselves. *Mathematics in Michigan,44*(1), 2-4.

Latterell, C. M. (2005b). Social stigma and mathematical ignorance. *Academic Exchange Quarterly, 9*(3), 167-171.

Mendick, H., Epstein, D., & Moreau, M.P. (2007). *Mathematical images and identities: Education, entertainment, social justice*. Full Research Report ESRC End of Award Report, RES-000-23-1454. Swindon: ESRC. Retrieved from http://www.esrcsocietytoday.ac.uk

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science*. Santa Monica, CA: RAND Corp.

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

Picker, S., & Berry, J. S. (2001). Your students' images of mathematicians and mathematics. *Mathematics Teaching in the Middle School, 7(*4), 202-208.

Picker, S., & Berry, J. S. (2002). The human face of mathematics: Challenging misconceptions. In D. Worsely (Ed.), *Teaching for depth: Where math meets the humanities* (pp. 50-60). New York: Heinemann.

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

Stetz, M. (2002, January 11). It all adds up at a conference. *San Diego Union Tribune*.

Wilson, J. L., & Latterell, C. M. (2001). Nerds? Or nuts? Pop culture portrayals of mathematicians. *ETC: A Review of General Semantics*, *58*, 172-178.

Wilson, P. S., & Chauvot, J. B. (2000). Who? How? What? A strategy for using history to teach mathematics. *Mathematics Teacher, 93*(8), 642-645.

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 1995* (pp. 785-794). Melbourne: Monash University.

Authors:

Carmen M. Latterell [corresponding author; clattere@d.umn.edu], Department of Mathematics/Statistics, University of Minnesota Duluth, 1117 University Dr, Duluth, MN 55812, USA; **Janelle L. Wilson,** Department of Sociology/Anthropology, 1123 University Dr, University of Minnesota Duluth, Duluth, MN 55812, USA.