

If Mathematics Were a Color . . .

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Students' beliefs, attitudes, emotions, and values toward a subject not only influence their interests and achievement, but also their actions such as their choices of course work, major, and career. In this study, middle school, high school, and college students' affective responses and perspectives toward mathematics were observed by using metaphors. The outcomes of the use of metaphors to learn about students' affective domains not only revealed the nature of students' affective domains regarding mathematics, but also students' justifications for those affective perceptions. Therefore, another aim of this paper is to model how teachers and researchers might categorize and interpret students' responses to reflect on not only the nature of students' affective tendencies, but also the reasoning behind them.

Introduction

There are different ways of expressing one's affective tendencies toward mathematics. These may include one's beliefs about mathematics such as, "mathematics involves too many rules to be memorized," or one's emotions as in "I get frustrated when studying mathematics." Attitudes, on the other hand, show one's positive or negative feelings toward mathematics, such as, "I like (or dislike) mathematics."

The main goal of this paper is to share an instrument involving the use of metaphors for assessing students' affective responses and perspectives toward mathematics. The main components in students' affective perspectives toward mathematics, such as beliefs, attitudes, emotions or values were studied. The outcomes of the use of metaphors to learn about students' affective domains not only revealed the nature of students' affective domains regarding mathematics, but also students' justifications for those affective perceptions. Therefore, another aim of this paper is to model how teachers and researchers might categorize and interpret students' responses to reflect on not only the nature of students' affective tendencies, but also the reasoning behind them.

In this study, middle school, high school

and college students' affective attributes towards mathematics were observed to reveal the nature of their affective domains. In particular, it was attempted to see which student group revealed more of their attitudes, beliefs, emotions or values and how this was related to their reasoning.

Definition of Terms

Eagly and Chaiken (1993) define attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (p. 1). However, we should not think of attitudes alone, because our attitudes are just part of our affective domain. McLeod and Ortega (1993) describe the affective domain regarding mathematics in terms of beliefs, attitudes, and emotions. DeBellis and Goldin (1997) argued for a fourth component, values. In their model, DeBellis and Goldin (2006, p.135) define these components as follows (See Table 1).

These beliefs, attitudes, emotions, and values towards a subject might influence a person's actions. Hart (1989) suggests that whether a person embraces or avoids mathematics implies a positive or negative attitude toward mathematics. Studies in mathematics education focused on students' affective domain concluded that

Table 1 Description of Terms

<i>Emotions</i>	Rapidly-changing states of feeling experienced during mathematical activity.
<i>Attitudes</i>	Orientations toward certain feelings in particular (mathematical) contexts.
<i>Beliefs</i>	Attribution of some sort of external truth or validity to mathematics.
<i>Values</i>	Deep, 'personal truths' or commitments cherished by individuals (includes ethics and morals)

students' attitudes, beliefs or emotions formed at the beginning of their education might affect their whole educational experience (National Council of Teachers of Mathematics, 2000). Moreover, students' attitudes influence their choices of course work, major, and career (Kanai & Norman, 1997; National Council of Teachers of Mathematics, 2000). Studies related to students' attitudes in the field of education indicate that grade level is a major variable affecting students' attitudes. Students' attitudes seem to change as they progress in their education. In particular, students' positive attitudes seem to decrease from elementary and middle school to secondary school (Kanai & Norman, 1997; McLeod, 1992; Wilkins & Ma, 2003).

Using Metaphors to Reveal Affective Domain

Thirty-one middle school students, 44 high school students, 34 pre-service mathematics teachers and 45 college students studying mathematics from the same university in Ankara, Turkey participated in the study. Many attitude-related studies use Likert-type scales in questionnaires where respondents choose a number between 1-4 or 1-6 to denote their reaction to sentences such as "I like mathematics." Those kinds of surveys provide information about the nature and strength of students' affective tendencies, but not about possible underlying reasons.

Rehner (2004) used a novel instrument to collect data about her participants' attitudes for her doctoral dissertation. Rehner cited an NCTM publication titled *Math-*

ematics Assessment: Myths, Models, Good Questions, and Practical Suggestions (Stenmark, 1991) for her instrument. This book offers a writing prompt using metaphors asking students to state what type of sound (shape, animal, etc.) they associate with mathematics, and then to explain their responses (for more information see p. 48). Employing the model offered by Stenmark (1991) and Rehner (2004), the survey used in this study asked participants to fill in the blanks for 10 open-ended statements such as "If mathematics was a kind of food (transportation vehicle, color, etc.), it would be _____. Because _____". Participants were not asked about their attitudes, emotions, or beliefs separately as in traditional questionnaires. Instead, they were provided with a neutral statement asking them to create a metaphor for mathematics. When explaining their metaphors, participants expressed their beliefs, attitudes, emotions, or values in their own words.

Overview of Responses

The analysis of participants' responses to the survey questions revealed that metaphors can be used effectively to study students' attitudes, beliefs, and emotions. Middle school students displayed more positive attitudes toward mathematics compared to high school and college students. Moreover middle school students' explanations were based much more on personal preferences than those of other participants. Therefore, their attitudes and emotions were easily observed. Undergraduate mathematics students and mathematics preservice teachers

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mainly mentioned much more of their beliefs about mathematics when discussing their affective domain. All participants brought their attitudes, beliefs and emotions forward more than their values when discussing their affective domain. In the following sections, students' responses to three specific questions will be shared.

Mathematics as Food

Participants mainly shared their beliefs and their attitudes in this category. Their positive personal preferences also surfaced in statements such as "if mathematics was a kind of food, it would be pasta, because it is the food I can never give up" (Undergraduate mathematics student). Or they shared their negative attitudes towards mathematics: "If mathematics was a kind of food, it would be eggplant; I do not like eggplant" (High school student).

When students discussed their beliefs about mathematics, some of the main categories that emerged were:

- ***Mathematics includes many things.***
If mathematics were a kind of food, it would be pizza, because it includes many types of food [toppings]. Mathematics is also very comprehensive (High school student).
- ***Mathematics is difficult.***
If mathematics were a kind of food, it would be spaghetti, because it is difficult to eat. It would be easy for those who know how to eat it (High school student).
- ***Mathematics requires hard work.***
If mathematics were a kind of food, it would be *mantı* (a Turkish dish similar to ravioli), because it is hard to prepare but it is delicious. Similarly mathematics requires hard work (High school student).
- ***Mathematics is beneficial in real life.***
If mathematics were a kind of food, it would be rice pilaf, because it could be a

side dish to every food; so it [mathematics] is included in every aspect of life (Mathematics pre-service teacher).

Some also shared their self confidence in this category: "If mathematics were a kind of food, it would be rice pilaf, because it is the food that I cook the best" (Mathematics undergraduate student).

It is important to notice that sometimes students' responses included both their beliefs and their attitudes. The student comparing mathematics to *mantı* mentioned that mathematics could be difficult and require hard work, but at the end they like it. Others mentioned the usefulness of mathematics in real life or finding mathematics difficult due to their previous experiences. Teachers could support the development of some of those beliefs with their instruction such as using real-world problems or valuing the hard work at the end of the problem.

Mathematics as a Transportation Vehicle

The main affective component overwhelmingly shared in this category was students' beliefs. A very few discussed their attitudes and emotions in this category. Students mentioned some of the same beliefs as in the food category such as mathematics requiring hard work or mathematics being beneficial:

If mathematics were a kind of transportation vehicle, it would be a bicycle, because you can advance only if you work very hard (Mathematics undergraduate student). If mathematics were a kind of transportation vehicle, it would be a car, because I can go everywhere with a car (High school student). Some of the new beliefs were:

- ***Doing mathematics takes time.***
If mathematics were a kind of transportation vehicle, it would be a train, because it proceeds with slow but safe steps (Mathematics undergraduate student).
- ***You need to be fast while doing math.***

Teachers could support the development of some of those beliefs with their instruction such as using real-world problems or valuing the hard work at the end of the problem.

If mathematics were a kind of transportation vehicle, it would be an airplane, because mathematics is a discipline which requires speed (High school student).

- ***Math includes connected subjects.***

If mathematics were a kind of transportation vehicle, it would be a train, because [in mathematics] everything is connected as with a train (High school student). If mathematics were a kind of transportation vehicle, it would be a boat, because you need to start at the shore in order to be able to go to deeper areas (Mathematics preservice teacher).

- ***Mathematics can provide different views (perhaps new ways of thinking).***

If mathematics were a kind of transportation vehicle, it would be an airplane, because it flies which is different from other vehicles; it looks at the earth from a different angle (High school student).

In this category, students mainly used their previous experiences and some of their views of the perceived usefulness of mathematics and its relation to real life when sharing their beliefs. Their previous K-12 schooling influences their beliefs about mathematics. At the same time, some students saw that doing mathematics may take time; but it is all right to take one's time to proceed with safer steps. At this point, after learning about students' similar beliefs, teachers could reflect on how their instructional practices might set the background for their students' beliefs. For example, teachers could emphasize that doing mathematics is not a race, because the rewards come from solving problems correctly, not for being the first to finish.

Mathematics as a Color

The color question revealed the attitudes and emotions of the students more than any other category. High school and especially

middle school students shared their likes, dislikes, or emotions about mathematics more so than college students.

If mathematics were a kind of color, it would be red, because I love red very much (Middle school student). If mathematics were a kind of color, it would be light yellow, because it's the color I hate the most (High school student).

Students also mentioned that mathematics could be as depressing as the color black or as refreshing and relaxing as the color blue or orange.

The color category also brought similar beliefs such as mathematics includes many things: "If mathematics were a kind of color, it would be a rainbow, because it includes all the colors" (High school student).

A couple of interesting quotes came from college students studying mathematics. They mentioned that "if mathematics were a kind of color, it would be black or white, because in mathematics a question has an answer or not," and "If mathematics were a kind of color, it would be red, because mathematics is a passion." If teachers uncovered such beliefs in their students, they might use open-ended problems or projects to help students see the grey areas of mathematics, not just those of black and white.

Discussion

The use of metaphors to uncover students' affective domain was valuable. Participants' attitudes, emotions, and especially beliefs and the underlying reasoning for those attributes were revealed through this fun, interesting activity involving the creation of metaphors. At the beginning of a school year, teachers can reveal their students' existing affective domain regarding mathematics by using a similar survey. Doing so can help teachers serve their students more effectively. For instance, if teachers detect that their students do not

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like mathematics because they view school mathematics as disconnected from real life, teachers can choose activities with more real-world applications. Or if teachers identify that their students believe that obtaining a speedy correct response is more important than working on a problem for an extended period of a time, teachers could highlight the importance of the journey as well as the destination. Through the use of exit slips each containing one or two prompts, teachers can follow up on students' affective domain periodically to observe if new attitudes, emotions, beliefs, or views are surfacing, or whether there are any changes in students' affective domains. Teachers could also allow students to be creative and more expressive by allowing them to choose the category that they will use in their analogies: "If mathematics were a kind of _____, it would be _____. Because _____."

The use of different categories for metaphors fostered different results. For instance the use of the color category revealed more attitudes and emotions than the other categories. The category of mathematics as a transportation vehicle intrigued participants so that they shared their beliefs with more explanation. The food category provided mixed results. Perhaps when it comes to concepts such as color, where personal preferences play more important roles, people are more open to say "because I like it." This would help us to see the direction of their attitudes and emotions. However, when asked about a vehicle or device, perhaps their thoughts are more focused on an explanation that would bring their beliefs forward. And those explanations would help us to see the reasoning that underlies students' affective domains. So when creating a similar instrument for a teacher or a researcher to use, maintaining a balance between the concepts that bring out more of the students' attitudes and emotions as

well as beliefs with logical explanations would be more beneficial. Then it would be possible to observe both their attitudes and emotions with direction and their beliefs with underlying reasoning.

Middle and high school students brought up more of their attitudes and emotions as compared to the college students. Undergraduate mathematics students and mathematics preservice teachers approached the activity with more logic and mainly shared their beliefs about mathematics rather than their attitudes or emotions. If an instructor wants to uncover college students' attitudes or emotions, questions like mathematics as a color would be more appropriate. On the other hand, if a teacher wants to reveal beliefs or views of middle school students, questions like mathematics as a transportation vehicle would be helpful.

Asking students to describe their attitudes and views about mathematics through metaphors, and also asking them to explain their metaphors, creates unique opportunities, not only for researchers and teachers to observe and study students' affective domains, but also for students to stop and reflect on their own attitudes, emotions and beliefs. When they do so, an opportunity opens for teachers to foster in their students positive attitudes, beliefs, and emotions regarding mathematics. Ω

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"The people that are out of work just don't match the types of jobs that are here, open and growing."

The increasing emphasis on more advanced skills raises policy questions about how to help low-skilled job seekers who are being turned away at the factory door and increasingly becoming the long-term unemployed.

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