Using Metaphors to Investigate Pre-service Primary Teachers' Attitudes Towards Mathematics

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Introduction

A number of studies have shown that negative attitudes and anxiety towards mathematics are common in pre-service teachers (see for example McNaught, 2010; Uusimaki & Nason, 2004). Thus, it stands to reason that pre-service teachers ought to be provided with opportunities to develop a more positive outlook when it comes to mathematics. In addressing this need, some mathematics educators have successfully adopted a range of approaches using writing tools and strategies to allow pre-service teachers to explore and articulate their views and attitudes towards mathematics (Di Martino & Zan, 2011; McNaught, 2010; Noyes, 2006). The value of using reflective writing tools and tasks lies in the potential for personal growth that can occur when engaged in such activities.

In this study, beginning pre-service primary teachers were asked to write a personal metaphor as a means to explore and articulate how they felt about mathematics. The use of metaphor as a reflective writing tool designed to explore views and attitudes towards mathematics has been embraced by a number of researchers in recent years (Noyes, 2006; Pesci, 2003; Schinck, Neale, Pugalee, & Cifarelli, 2008). The value of metaphors is not just that they are a simple linguistic tool that can be used to better understand a concept, but that they are an instrument that can be used effectively for deeper introspection. In this respect, metaphor may be an important tool for developing critical thinking. While varied definitions of critical thinking abound, Mason (2007) has pointed out that one key perspective is that of being able to "understand the bigger picture holistically, to see different worldviews in perspective, rather than just to critique the individual steps in a particular argument" (p. 341). Recent research by Phelan (2001) has emphasized that critical thinking is not solely based on reason, but involves compassion and emotion, such as in the way one responds to the death of a child. It may be that the use of metaphor to encourage reflection in a way that incorporates deep-seated emotions facilitates the development of critical thinking skills.

Background

Accounts of negative attitudes toward mathematics amongst pre-service teachers abound in the literature (Brady & Bowd, 2005; Di Martino & Zan, 2011; McNaught, 2010). Many of these negative attitudes are the result of prior adverse experiences as school students in mathematics classrooms. According to Drake, Spillane and Hufferd-Ackles (2001), stories of previous mathematical experiences described by pre-service teachers in their study are "dominated by disappointing and discouraging experiences learning mathematics in school. In addition, they all recall losing interest, confidence, or aptitude in mathematics at some time during their elementary or early high school years" (p. 7). There is also strong evidence that as a result of negative school mathematics experiences, many pre-service primary teachers have mathematics anxiety and see themselves as unable to learn mathematics (Uusimaki & Nason, 2004; Wilson & Thornton, 2005; Wolodko, Willson, & Johnson, 2003). Thus, according to the literature, pre-service primary teachers typically are likely to hold negative beliefs and attitudes, and to lack confidence with regards to mathematics.

These research findings have most certainly been reflected in our experience as pre-service teacher mathematics educators. Since 2012, we have been teaching Elements of Mathematics, a core mathematics content topic for all first-year early childhood and primary

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pre-service teachers. Our students are generally an obliging and content group who usually approach their studies with enthusiasm and good humor. But when it comes to mathematics, our experience has been that their positive attitude, in the main, evaporates. They would rather do almost anything else than be present in their mathematics workshop. McNaught (2010) has recounted similar experiences by highlighting the total reluctance, if not repugnance, of his pre-service primary teachers to studying mathematics. What is of greatest concern to us is that our students seem not to have given any thought to the notion that they will indeed be mathematics teachers in the future, and that this will be a significant component of their teaching responsibilities. Our reality has been that our students see this topic as something to be endured, rather than a learning opportunity that will prepare them to teach mathematics enthusiastically and competently. It became obvious to us that we needed to highlight to our students that whilst their views and attitudes toward mathematics are fairly commonplace, they represent a significant learning barrier that needs to be addressed. We decided to provide the students with an opportunity to use personal mathematical metaphors to aid them in identifying and articulating their feelings about mathematics, with the ultimate aim of helping them to start reacting more positively.

Contemporary Metaphor Theory

The use of metaphors as a theoretical means for framing beliefs and attitudes has been argued well by Lakoff and Johnson (2008) and Ashton (1994). According to Lakoff and Johnson, metaphors are of key importance in meaning-making because creating metaphors helps us to structure our experiences. They assert that "the essence of metaphor is understanding and experiencing one kind of thing in terms of another" (p. 5). Thus, metaphors are more than just a linguistic device; they represent embodied knowledge and lived experiences (Chapman, 1997). However, as Ashton explained, another "essential feature of metaphor is that it demands the interpreter becomes actively involved in searching for a meaning" (p. 358). To this end, metaphors are an ideal tool for researchers to elicit an understanding of how their respondents make sense of the world around them. In this study, through the use of metaphor, our students used inventive concepts and contexts to create strong and meaningful images to articulate how they felt about mathematics. Many of the metaphors developed by students can be argued to be "strong" as defined by Black (1993); a couple of examples are highlighted in the results section. Black argued that strong metaphors are both markedly emphatic and resonant. Emphatic metaphors are meant to be "dwelt upon for the sake of their unstated implications" (p. 26); resonant metaphors "support a high degree of implicative evaluation" (p. 26).

Research Method

The participants in this study were first-year pre-service teachers enrolled in either early childhood or primary teacher education programs. All of these students were required to complete a core topic (other institutions may alternatively refer to units or courses) entitled Elements of Mathematics in their second semester of study. This is a mathematics content topic designed to provide the students with the mathematical grounding they require to effectively teach mathematics in either an early childhood or primary setting. Of the over 250 students enrolled in this topic, 104 provided informed consent for the personal mathematics metaphor to be used as data in this study.

The mathematical metaphors were written as the culmination of a workshop teaching activity in the first week of the topic. This teaching activity drew upon a similar exercise that was conducted by Gibson (1994) in a high school setting. The workshop leaders took the students through a series of steps to encourage them to reflect upon their attitudes toward mathematics, doing mathematics, and studying mathematics. Firstly, the students were asked to write a list of words or phrases they might use to describe mathematics. Secondly, the

students wrote words or phrases to describe what doing mathematics, or using mathematics, felt like to them. Thirdly, the students constructed a list of things or objects they thought *best* described what mathematics seemed like to them. Finally, the students wrote their personal metaphors to describe the ways the thing or object they had selected and mathematics are similar, thinking in particular about how this metaphor described their feelings about using or doing mathematics. It was suggested that the students commence their metaphor with this introduction: "For me, mathematics is like a …."

The data analysis occurred in two coding phases. In the first phase, the metaphors were coded according to three core themes as adopted from the work of Di Martino and Zan (2011). The three core themes were the students'

- Emotional Disposition to mathematics, as expressed in terms of "I like/dislike mathematics";
- Vision of Mathematics, expressed as "Mathematics is a …"; and
- Perceived Competence with mathematics, as expressed in terms of "I can/can't do it."

The second phase of the coding used an approach similar to that adopted by Schinck et al. (2008), and involved determining sub-themes from within each of the core themes.

Findings and Discussion

Core Themes and Sub-themes

Within each of the core themes, a range of sub-themes emerged in the second phase of the coding process. With regard to those metaphors that expressed an emotional disposition to mathematics, both key sub-themes were quite negative in nature, namely that mathematics is Frustrating/Defeating, and that mathematics is a Necessary Evil. None of the metaphors expressed a positive emotional disposition to mathematics. For those metaphors that primarily expressed a vision of mathematics, a larger range of sub-themes was evident. Mathematics was variously described as a Structure; a Skill; a Tool; a Puzzle, Game or Sport; or an Environmental Feature. Finally, within the core theme that principally expressed a perceived competence at mathematics, two key sub-themes emerged: that mathematics Requires Effort, and that doing mathematics has its Ups and Downs.

Many of the metaphors needed code categorisation into more than one core theme or sub-theme. Of the 104 mathematics metaphors that were analysed, a total of 173 distinct theme codes were evident; 44 of the metaphors were categorised as having just one distinct theme, 49 as having two themes, and 10 as having 3 or more key themes. The Computer metaphor is a good example of a metaphor with more than one theme:

> Maths is like a computer. It can be used to do complex and simple things. Different people use it with different levels of confidence and ability. Sometimes it appears to fail for no reason, but it fails due to processes not working out as it should.

The student's metaphorical use of mathematics as a computer adopted the mathematics as a Tool sub-theme, but the student then went on to describe how the computer might unexplainably break down, which led into the mathematics is Frustrating/Defeating sub-theme. This metaphor exemplifies the complex nature of many of the metaphors and why categorisation into a single theme would not have adequately captured the richness of the students' metaphors. Table 1 presents the percentages of metaphors containing codes

categorised into each core theme or sub-theme.

Table 1 *Core Themes and Sub-themes in Personal Mathematical Metaphors*

Core Theme	Sub-theme	Occurrence in metaphors (%)
Emotional Disposition	Frustrated/Defeated	20
	Necessary Evil	13
Vision of Mathematics	A Structure	14
	A Skill	14
	A Tool	12
	A Puzzle/Game/Sport	9
	The Environment	22
Perceived Competence	Requires Effort	43
	Ups and Downs	19

Emotional Disposition

The students' Emotional Dispositions to mathematics were primarily expressed in 33% of the metaphors. What is most significant is that these metaphors were entirely negative in nature; not a single metaphor expressed anything that came close to a positive emotional disposition to mathematics. The metaphors revealed, at best, some students' ambivalence towards mathematics, as described in the mathematics as a Necessary Evil theme:

> To me mathematics is like that one thing you love to hate eg the Collingwood Football Club. I wish that they didn't exist but realise that the competition needs them to make it interesting. You can't live them but you can't live without them.

> For me mathematics is like being stuck in the traffic, although you don't enjoy it there is no way to avoid it if you want to get to your destination.

> For me mathematics is like the yuck vegetables on the plate, I don't like them but will eat them anyway.

However, other metaphors that expressed the students' emotional disposition to mathematics were far more discouraging. Some students used their metaphor(s) to describe how they were Frustrated/Defeated by mathematics:

> Maths is like shopping for jeans. Frustrating and I usually just give up after a while.

> Maths is like an electrical circuit. When all of the components are in place a light bulb will turn on. When a component breaks down, you're in the dark.

> Maths is like a bag of Allen's snakes. You only want the red and blue snakes because they taste good, but you have to deal with the orange and green snakes.

Yet other metaphors articulated the palpable fear that mathematics instills in some of the students:

> Math is like riding a horse wearing a blindfold.

> Maths feels like being stuck in space without a helmet, never-ending, overwhelming and quite fatal.

Visions of Mathematics

Visions of Mathematics was the most prevalent of the categorised theme codes. Seventy-one percent of the student metaphors principally included such a classification. This ought not to be surprising as the students were guided in the teaching activity to think of an item or object which best described what mathematics seemed like to them. Of note is that with little or no prompting, the items or objects that the students selected form a reasonably small group of sub-themes that mostly reflect a utilitarian view of mathematics. The metaphor of mathematics as A Tool is a clear example of this point of view:

> For me mathematics is like a car because I can understand the basics like how to drive it but once it gets to the harder stuff like how the engine works I am stuck.

Similarly, the metaphors for mathematics as A Skill also adopted a utilitarian position. A number of students drew upon the skills involved with cooking:

> Maths is like baking a cupcake. If you don't follow the recipe or use the wrong ingredients they don't turn out properly.

> Maths is like making a meal when you're hungry. It takes time and effort but once you're finished cooking and you eat, you feel satisfied with your accomplishment.

Then again, a range of other interesting skills was also offered. Of note in these metaphors is the more positive attitude toward mathematics that is expressed:

> For me maths is like riding a bike, once you've figured out how to do it, it's easy.

> For me mathematics is like jumping into deep water. It is scary at first but if you have already been taught the basics of swimming you can keep afloat.

> For me mathematics is like reading a map overseas. You look at it and recognize some aspects and symbols. Sometimes you can find out where you are going, other times you are completely lost and confused.

Students' mathematics as A Structure metaphor reflected an appreciation of the order and pattern that characterises mathematics:

> For me maths is like a hamburger because it's complex, has many layers, involves time, is unique, and sometimes difficult to swallow.

> Maths is like an electrical circuit when all of the components are in place the light bulb comes on. When a component breaks down the circuit is cut, and you're left in the dark.

> Maths is like an airport: it looks chaotic but everything is actually following logical, pre-determined rules.

On the other hand, mathematics as A Puzzle, Game or Sport also attracted reasonable favorability. Of note in these metaphors are reflections that will be addressed further in the next section, that is mathematics as having its Ups and Downs, and that it Requires Effort:

> For me maths is like a jigsaw puzzle. It can be overwhelming at the start with all the pieces mixed up. But when you sort through and find the framework it becomes easier. Focusing on one section at a time to make the bigger picture makes it easier to solve and complete the puzzle.

> For me mathematics is like surfing, sometimes you can hang ten but sometimes you wipe out.

> For me mathematics is like a game of paintball. Your head says stop and hide at every obstacle so you don't get embarrassed; your heart says get out there and shoot down anything that comes your way. You may get hit a few times, but picking yourself up and trying again is the only way to succeed.

Finally within this core theme, a number of students selected aspects of the Environment for their mathematical metaphor. For some, the environment, like mathematics, needed to be approached with caution:

> Maths is like the pitch-black darkness we encounter throughout the middle of the night. Scared of the unknown and just waiting for it to end and the light of day to shine through.

> Maths is like an intimidating spider. It manages to crawl into every situation, constantly hovering around until you exterminate the pest.

For others, the Environment metaphor was ideal, as it could be used to express the Ups and Downs in doing mathematics (which will be further discussed in the next section):

> Maths is like a thunderstorm – chaotic to start with when learning the new concept. But when it all clicks it's like the rainbow at the end.

> It would be like the weather in Adelaide, one minute the sun is shining and the next its cold and raining. Just like maths, one minute you feel accomplished but the next you feel as if everything you don't understand is raining on you.

> For me mathematics is like the ocean – calm and endless but like an ocean one wrong move or calculation and you will come crashing down only to end up at the beginning of the shore.

Pleasingly, a few students were able to find more positive metaphors for mathematics by drawing upon the environment:

> Maths is like walking through a vast rainforest, full of wonders, and the more you know the more fascinating it becomes.

> Maths for me is like a snowstorm. Firstly it looks cold and terrible but once you have the right warm clothes you can see the beauty of the snow.
>
> For me maths is a fresh breeze, it's fun to walk through, though sometimes the wind is strong and you can't move on for a bit but you're fine in the end.

Perceived Competence

In the main, the students' perceived mathematical competence underpins many of their metaphors, to the extent that 62% of them contain a clear indication of this core theme. Given the depth of negativity toward mathematics that seems to pervade our student cohort, we were surprised to find within this core theme that the students' metaphors revealed reasonably positive sentiments when it came to their perceived mathematical competence. The first of the two principal sub-themes in this regard was that mathematics Requires Effort. These metaphors illustrate the degree of effort the students' believed was required for mathematical pursuits, and many also expressed the feeling of satisfaction that results from being successful. For instance:

> For me mathematics is like a roller coaster because you put a lot of courage in some cases going onto it and doing it. And after a crazy ride you get off the roller coaster that is maths, and feel pride for having done it.
>
> For me maths is like a long steep incline that plateaus at an icecream shop. There are bumps, cracks and holes along the way, some big and some unnoticeable. At the end, when it's all over, relief and pride fill you. It's good to treat yourself to an icecream after such a great accomplishment.
>
> For me mathematics is like exercise. It can make you feel accomplished but can also make you sore. Although it is beneficial and important, it is at times hard to get started and to keep going but it is worth it to pull through.

For other students, mathematics comes with plenty of challenging Ups and Downs and perhaps not always a successful outcome. The roller coaster metaphor appears again in this sub-theme, but this time it was not expressed as such a pleasurable experience:

> Maths to me is like a roller coaster. One minute you are happy and enjoying it because you understand it. Next minute you come down and are really anxious because you don't understand it.

The Ups and Downs of doing mathematics were also evident in a range of other descriptive metaphors:

> Maths is like a TV signal, sometimes its crystal clear and fun to watch, where other times it just doesn't work, making it a frustrating challenge to fix.
>
> Maths can be like a rainbow, before it gets pretty there is a bit of a storm.
>
> Maths is like watering a plant. A little amount of water added at a time can be beneficial and nutritional but too much at once can feel like you're drowning.

The findings of this study indicate that the first-year pre-service teachers have complex attitudes and views regarding mathematics, as revealed in their personal mathematical metaphors, which have been coded according to core themes identified by Di Martino and Zan (2011). Interestingly, these themes are in a different sphere from the root metaphors identified by Noyes (2006). He found that metaphors from pre-service teachers used to express beliefs about mathematics and its learning and teaching fall into four root categories: structure, language, journey and toolkit. While many of the metaphors in this study express one or more aspects of these root metaphors, especially those metaphors that express an emotional disposition towards mathematics, such as mathematics being a necessary evil, they do not easily fit into one of these categories. It may be that the emphasis in this study on asking students to think about what doing mathematics *felt* like resulted in a different range of metaphors from those generated from a focus solely on beliefs about mathematics, and may explain why the metaphors appear better suited to the applied categorisation.

Many of the metaphors developed by students were strong metaphors, as they were both emphatic and resonant (Black, 1993). For example, the metaphor "Maths is like riding a horse wearing a blindfold" is markedly emphatic because it allows the reader to dwell on a variety of unstated implications, and notably resonant because it lends itself to much implicative evaluation. On reading the metaphor, the reader might wonder how frightening it would be to ride a horse blindfolded, whether the rider would fall off or die, and what such a feeling means for a person's capacity and confidence to do mathematics. As another example, the metaphor "Maths is like shopping for jeans. Frustrating and I usually just give up after a while" is another strong metaphor. It leaves the reader pondering why shopping for jeans is frustrating, perhaps because finding a size that fits is too hard, or because the fashions available do not suit the shopper, or for some other reason. The reader might wonder whether the author of the metaphor feels like finding a solution to a problem that "fits" is just as hard, and so not worth the effort in the end.

Whilst we had originally perceived a generally negative attitude toward mathematics amongst the student cohort, the metaphors did not overwhelmingly reflect this. Certainly, a few of the metaphors expressed strongly negative views, but most students found more of a middle ground in their metaphors, revealing a potential preparedness to approach mathematics more positively. East (2009) contended that metaphors "can foreground new perspectives and new insights" (p. 22). In this study, by encouraging our students to explore their attitude toward mathematics through personal metaphor, we may have been partially successful in achieving this outcome.

In addition to this, an important consideration has been not only what the metaphors would reveal to us about our students, but also how beneficial this exercise might have been for them. While we did not explicitly measure the value of the exercise and whether it changed student perceptions of mathematics, we know from previous research that metaphors are an important learning tool. Kaminski (2003) showed that increasing reflective thinking is likely to improve understanding of mathematics, and generating metaphors is one way of improving reflective thinking. Lakoff and Nunez (2000) added weight to Kaminski's claim, arguing that improving reflective thinking through metaphors is important for learning in mathematics. From a critical thinking perspective, improving reflective thinking is important because reflective thinking is critical for opening up new perspectives by understanding that a given perspective is not the only possible one (Mason, 2007). The metaphors that students developed required them to think reflectively; part of the aim of this study was to encourage students both to be more aware of their perspectives on mathematics and also to potentially open up new perspectives. It did appear to be the case that the students were significantly engaged in the activity during class, as they were eager to share their metaphors with others and to hear what their classmates had written. This incidental class discussion appeared to result in the students

openly reflecting on their attitude(s) toward mathematics. Thus, creating personal metaphors for mathematics, as foreseen by contemporary metaphor theory, did result in the pre-service teachers thinking in a more in-depth manner about how they viewed mathematics.

Conclusion

In this study, we have adopted a metaphor-theory framework to explore the attitudes of our students, first-year pre-service early childhood and primary teachers, toward mathematics and to provide them with a means to perceptively reflect on these attitudes. The personal mathematics metaphors that the students created incorporated inventive concepts and contexts to express strong and meaningful images of how they felt about mathematics. Three core themes were adopted to analyse what the metaphors revealed about the students' emotional disposition toward mathematics, their vision of mathematics and their perceived competence in mathematics. The findings of this study reveal that the first-year pre-service teachers have complex attitudes and views regarding mathematics. However, despite our perception that our students generally had quite a negative attitude toward mathematics, the metaphors exposed that, in the main, there existed a potential preparedness among the students to approach mathematics more positively. The metaphors developed by students clearly demonstrate that students have engaged in reflective thinking through generating the metaphors. Given that existing research has demonstrated the importance of reflective thinking for developing critical thinking, deeper introspection, and better understanding of a concept, we offer two key conclusions from this albeit reasonably small-scale study: first, that metaphor theory holds further promise as an effective means for exploring pre-service teachers' attitudes and views about mathematics and their roles as learners and future teachers of mathematics; second, that metaphor theory is an important learning tool for students themselves to increase their self-awareness of their attitude(s) toward learning mathematics, and open their attitudes to change. Perhaps the knowledge gained by teacher and student can work in tandem to facilitate learning and teaching of mathematics.

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