Alberta Journal of Educational Research, Vol. 62.2, Summer 2016, 168-183

Early Years Students' Relationships with Mathematics

Miwa Aoki Takeuchi, Jo Towers, Jennifer Plosz

University of Calgary

Early years mathematics experiences have been shown to be a significant predictor for students' school readiness and future mathematics achievement. Previous research also indicates an important connection between emotion and mathematics learning. How do students in early years education in Alberta describe their emotional relationship with mathematics? This article documents the findings of our research focusing on Kindergarten to Grade 2 students. Our analysis showed that many students in the early years, including those at the Kindergarten level, recognized what is considered to be mathematics but mainly associated mathematics with number and numerical operations. The majority of these students reported positive relationships with mathematics, though some described negative relationships with school mathematics learning.

Les expériences préscolaires avec les mathématiques se sont avérées être des prédicteurs importants de la maturité scolaire des jeunes enfants et de leur rendement en mathématiques à l'avenir. La recherche a également révélé un lien important entre les émotions et l'apprentissage des mathématiques. Comment les jeunes Albertains décrivent-ils leur relation émotionnelle avec les mathématiques? Cet article explique les résultats d'une recherche portant sur des élèves de la maternelle à la 2e année. Notre analyse démontre que plusieurs jeunes élèves, y compris ceux de la maternelle, ont reconnu ce qui est considéré comme étant les mathématiques, mais que pour eux, les mathématiques sont surtout liés aux chiffres et aux opérations numériques. Alors que la plupart de ces élèves ont indiqué qu'ils avaient un rapport positif avec les mathématiques, certains ont décrit des liens négatifs par rapport à l'apprentissage des mathématiques à l'école.

Recently, mathematical experiences developed during the early years have been highlighted as a significant predictor for students' school readiness and also for future mathematics achievement (Duncan et al., 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009). Early mathematics skills, including the knowledge of numbers and ordinality, were identified as one of the most powerful predictors for later school readiness (Duncan et al., 2007). Jordan, Kaplan, Ramineni, and Locuniak (2009) focused on children's number competence, which is about seeing the value of small quantities immediately, making judgments about numbers, and grasping counting principles. According to these authors, number competence was considered to be developed during children's play in the early years and was identified as a good predictor for later school mathematics outcomes. Together, these studies indicate the significance of paying close attention to children's early mathematical experiences.

In order to deepen our collective understanding of students' mathematics learning experiences in schools, researchers have begun to examine students' emotions in learning

mathematics; however, as yet, few studies have investigated students' experiences in the early grades (Di Martino & Zan, 2010; Larkin & Jorgensen, 2015; McDonough & Sullivan, 2014). Our own research examining students' mathematical autobiographies—first-hand accounts of the experience of learning mathematics—is providing initial insight into students' images of mathematics and their feelings about learning mathematics across the age range from Kindergarten to post-secondary (e.g., Hall & Towers, 2014; Hall, Towers, Takeuchi, & Martin, 2015; Towers, Takeuchi, Hall, & Martin, 2015, 2016). In this article, we focus in particular on the data we collected during autobiographical interviews with students in Kindergarten to Grade 2.

Literature Review

Our main focus for this paper is to provide an overview of early years students' emotional relationships with mathematics based on their autobiographical accounts. During our research we also sought to understand whether and how children in early years education know and understand what mathematics is. To contextualize these foci of our analysis, we review literature in two interrelated areas: children's feelings toward mathematics, and where and how children encounter mathematics.

Children's Feelings toward Mathematics

Mathematics education research about affective factors has been conducted since the 1960s, with early studies focusing on mathematics anxiety and attitudes toward mathematics (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Ashcraft & Kirk, 2001; Di Martino & Zan, 2010, 2011; Young, Wu, & Menon, 2012; Zan, Brown, Evans, & Hannula, 2006). Examining children's feelings toward mathematics is significant because a) one of the major goals of early childhood mathematics instruction is to foster a productive disposition (including curiosity, imagination, inventiveness, risk-taking, creativity and persistence) and encourage children's views of themselves as capable of thinking mathematically (Clements & Sarama, 2014; Sarama & Clements, 2009); and b) research into affective domains (beliefs, attitudes, and emotions) has indicated an important, and inseparable, relationship between cognitive and emotional or affective mathematical realms.

However, young children's feelings toward mathematics have not often been addressed in previous studies, in part due to the methodological challenges of eliciting information from very young children (Kindergarten, Grade 1, and Grade 2 students) about their emotional landscape. Within the body of literature that does concern very young children's relationships with mathematics, an experimental study conducted by Rader and Hughes (2005) showed how positive emotion (i.e., feeling happy) could improve the performance of a block design task for Grade 1 and 2 students. There have also been neuropsychological discussions on how positive emotions could facilitate cognitive flexibility and influence long-term memories, working memory, and problem solving (Ashby & Isen, 1999). These studies tended to identify emotions with researchers' words, for example, by inducing certain affect through presenting a happy and a sad story (Rader & Hughes, 2005). Instead, we hoped to listen to what children have to say about their relationships with mathematics in their own words.

In order to gain access to students' opinions, attitudes, and thoughts, previous studies have used creative methods beyond verbal interviews. For example, McDonough and Sullivan (2014) utilized children's drawings, video clips, and photographs of school, home, and other everyday

activities with their 8 to 9 years old participants. Larkin and Jorgensen (2015) used iPad video diaries to investigate attitudes and emotions towards mathematics among Grade 3 and 6 students. In this study, we utilized autobiographical interviews as well as the children's own drawings to reveal aspects of their feelings that might not necessarily be obtained merely from verbal interviews.

Where and How Children Encounter Mathematics

Children's emotions toward mathematics cannot be separated from the contexts in which they encounter mathematics. In looking into children's mathematical experiences, we reviewed previous studies identifying where and how children encountered mathematics in the early years. During the early years, children can develop a wide variety of mathematical concepts, not only from formal instruction but also from everyday practices in which they are involved, such as play. Researchers have noted that play, in particular, is a meaningful context within which children can develop mathematical concepts, symbolization, and representation, with or without adult guidance (Charlesworth & Leali, 2012; van Oers, 2010). Previous research identified that through play children develop key concepts including one-to-one correspondence, arithmetic and counting, estimating, spatial reasoning, measuring, understanding shapes, logical classification, comparing, ordering, and understanding parts and wholes (Charlesworth & Leali, 2012; Clements & Sarama, 2014; Ginsburg, Inoue, & Seo, 1999; Ginsburg, Lee, & Boyd, 2008; Ginsburg & Seo, 1999). For instance, children are often involved in role-play settings (such as playing supermarket, museum, railway station, travel agency, post office, construction site, and so forth), where they encounter mathematical problems and tasks (van Oers, 2010). While children can experience rich mathematics learning opportunities through play and daily activities, children, parents, and early childhood educators may not necessarily recognize those opportunities as mathematical.

Despite the aforementioned richness of mathematical experiences children can have during play in their early years, previous research has identified that most early childhood educators tend to focus mathematical instruction on a narrow range of mathematics content (Ginsburg et al., 2008). There are a number of reasons why this might be the case. For example, in the Alberta Program of Study for Mathematics in the Kindergarten to Grade 2 grades, there is an emphasis on concepts relating to number sense. More than 40 % of the expected outcomes for Kindergarten and Grade 1 mathematics fall within the number strand. Also, it has been reported that early childhood educators tend to lack confidence in teaching mathematics and thus teach a narrowed range of mathematics content in Kindergarten (Sarama & Clements, 2009; Ginsburg et al., 2008). As such, it is important to understand how children perceive what counts as mathematics through their encounters with mathematics instruction and mathematical experiences in the early years. In our study we sought to understand what young children see as "mathematics" and to explore their emotional relationships with this discipline.

Methodology and Methods

The methodological framework of narrative inquiry shaped our exploration of early years students' emotional relationships with mathematics. The goal was not only the gathering of narratives—written, oral, visual—but more that through these narratives we sought to focus on the meanings students ascribe to their experiences, providing "insight that (befits) the

complexity of human lives" (Josselson, 2006, p. 4). Our desire is to understand students' experiences, not simply to gather an accurate retelling of events. As Riessman (1993) also stressed, "a personal narrative is not meant to be read as an exact record of what happened nor is it a mirror of a world 'out there'" (p. 64). A child's personal narrative is a construction within social contexts and is something that intercedes between self and culture. This narrative inquiry focuses "not only on individuals' experiences but also on the social, cultural, and institutional narratives within which individuals' experiences are constituted, shaped, expressed, and enacted" (Clandinin & Rosiek, 2007, pp. 42-43). Such views on the three-way construction among self, narrative, and culture serve as the basic assumption in this study.

We examined oral and written mathematics autobiographies together with drawings of how students feel when doing mathematics and what they think mathematics is. The data for our study were gathered from students from Kindergarten through to post-secondary levels, as well as from members of the general public, in the Canadian provinces of Alberta and Ontario. We conducted 131 face-to-face interviews with students from Kindergarten to post-secondary (94 Kindergarten to Grade 9 students, 31 Grades 10 to 12 students, and six post-secondary students) and, through an online environment, collected written or multi-media mathematics autobiographies from 91 members of the general public, most of whom were also post-secondary students. This article focuses on interviews with 39 students (25 boys and 14 girls) from Kindergarten to Grade 2 classrooms in Alberta.

Regarding the construction of the actual interview process, informed by narrative inquiry, we attended to both voice and structure. While interviewing, we strove to interact with our participants through a supportive voice, "pushing the narrator's voice into the limelight ... creating a self-reflective and respectful distance between researchers' and narrators' voices" (Chase, 2005, p. 665). We collected children's autobiographies through both a circular and chronological construction of prompts from the researcher/interviewer. Prompts were circular in that some that were given near the beginning of the interview were re-prompted in a slightly different form near the end. Also, prompts were chronologically constructed as students were asked to reflect on their earliest memories near the beginning of the interview, then invited to discuss their more recent and current mathematical experiences, and finally prompted regarding their future outlook near the end of the interview. It is through the attention to voice and structuring of prompts that we looked to aid in the expression of the sharer's understandings, perspectives, and experiences.

Concerning the topics of inquiry for our semi-structured interviews, prompt questions included eliciting students' feelings towards mathematics and their relationships with mathematics, details of the learning environments they were in currently and had experienced in the past, experiences of learning mathematics at home, and their exposure to mathematics outside school and through media such as movies and books. Regarding our prompts for drawings, we asked students to draw something that represented what they thought mathematics is and also to draw how they feel when they are doing mathematics. Once they completed their drawings, they were asked to explain what they drew.

All interview data was transcribed. Qualitative analysis of transcripts was conducted by a group of researchers within the team. We looked at each interview thoroughly. On account of our focus on early years students, we started our analysis by examining what young children thought mathematics was. We did this by initially considering their oral response, early in the interview, to a question about whether they knew the word "mathematics" and could tell us what that meant. Rather than merely focusing on this specific question, we looked at the interview

entirely to listen to children's narratives carefully. As an entry point to students' emotional experiences with mathematics, we began by analyzing participants' verbal responses to the interview question, "How do you feel when you are doing mathematics?" For the first round of analysis, we focused on distinguishing students' positive and negative relationships with mathematics. Positive relationships were identified when students reported that they felt good and/or confident about mathematics, liked mathematics, and/or found mathematics to be fun, enjoyable, and exciting. In contrast, negative relationships were identified when students reported that they felt confused about mathematics, did not like mathematics, and/or reported themselves to be struggling and/or bored. However, we did not treat children's emotions as a positive/negative binary. For example, the state of frustration and confusion can be experienced along with the sense of accomplishment and fulfillment in doing mathematics. Our process included a more nuanced analysis, which was sensitive to subtle textures of students' feelings and involved examining students' narratives in their entirety, including the drawings that they generated and their explanations of their drawings, in order to pay careful attention to details of their experiences. In this phase of the analysis we categorized students' emotional relationships as positive, negative, mixed, and changing. In calculating the frequency of each code, we excluded the students who a) did not seem to understand the question, b) chose not to answer, and c) decided not to draw or did not describe what their drawing was. The coding was completed collectively as a research team by using the analytic software, *NVivo*. As follows, we present both the percentage of each code and excerpts from student interviews as well as some of the representative student drawings.

Drawings were analyzed thematically, with repeated sortings using guiding themes developed by the research team. These themes included analyzing the drawings by grade level, by the gender identity of the student, and by the category of features included in the drawing (e.g., representations of school mathematics environments or representations of individuals versus groups of students), to name just a few of the analytical themes we addressed. Based on students' descriptions of drawings, we coded feelings represented in the drawings in a similar way that we coded feelings in their oral responses: these were positive, negative, mixed, and changing. In analyzing drawings, we used two additional categories: neutral and non-emotional. "Neutral" was when students described, for example, "I don't feel too happy or too sad about it so I would say I'm in the middle." "Non-emotional" was used when students drew a picture (for example, a map) but did not attach particular emotions. Drawings were also analyzed in relation to the narratives, with particular attention paid to differences between the emotions described in speech and those portrayed through drawing.

Findings

In this section, we highlight the following main findings. First, we discuss whether and how students in the early years recognized mathematics. Then, we introduce our findings concerning students' relationships with mathematics. Finally, we provide some of the commentary made by students on the mathematics pedagogy they had experienced in early years classrooms that seemed intimately connected with how they felt about mathematics as a discipline.

Students' Knowledge about Mathematics

Overall, our interviews demonstrated that early years children, including Kindergarten students,

could recognize and engage with what is considered to be mathematics. Yet, although the majority of students were able to provide a response to prompts designed to elicit their impressions and understandings of what mathematics is, their responses were all very similar and focused almost exclusively on number concepts. The following example is representative of the majority of responses.

> Interviewer: Do you know what math is?
> Participant: Yes.
> Interviewer: What's math?
> Participant: It's like adding and subtracting.
> Interviewer: Okay. And what else is math? Do you know? Any other stuff?
> Participant: Math is like, like questions, like if I know, then I know. If I know twenty-one plus ten is thirty-one, then I know, then it's one more added or like ten more added or like.

As seen in this interaction, many students were able to identify numbers and number operations as mathematics, yet few associated other areas within the mathematics curriculum and with the discipline of mathematics—such as patterning, sorting, shape, space, and modeling. Occasionally, some students had a broader conception of mathematics and could give examples. For example, a Kindergarten student described her earliest memory of mathematics and identified sorting as a form of mathematics as follows.

> Interviewer: What's the very first thing you can remember in your life that, that was to do with math?
> Participant: Let's see. I know that it's sorting.
> Interviewer: Yep.
> Participant: That's math.

When we asked where she learned "stuff about sorting," she explained about the informal opportunities to engage in mathematics and sciences at home. For example, she said she often observed her brother and friends doing experiments and she also engaged in sorting through cleaning up her toys after playing (e.g., sorting animal toys and people toys into different boxes). She also explained that, "I usually watch him do science shows with his friends." For her, science and mathematics did not have a clear boundary. As we noted above, though, students who mentioned anything other than number as mathematics were in the minority.

Students' Relationships with Mathematics

As seen in Table 1, our research shows that the majority of children in the early years (Kindergarten to Grade 2) reported positive relationships with mathematics: 70.5 % of the children reported positive feelings (e.g., feeling happy, feeling good) and/or reported that they liked mathematics. 20.5% of the children reported negative feelings (e.g., tiring, boring, struggling) and/or reported that they don't like mathematics and 8.8% of the children reported mixed feelings towards mathematics (e.g., I feel both happy and not happy, I feel good and bad). While we had another coding, changing, that denotes a change in the student's relationship with mathematics, we did not code any data with this code for students in the early years. We did observe changing relationships among older students.

When asked to draw a picture illustrating how they feel when they are doing mathematics, the majority of the students explained that their drawing represented positive feelings, as shown

in Table 2. 75.7 % of the students drew pictures to indicate positive feelings (e.g., happy, fun), whereas only 9% of the students drew pictures representing negative feelings (e.g., bored, struggling, not liking math). Many children drew a smiling face to indicate happy feelings when doing mathematics and a smiley face was the most commonly observed picture. For example, a Kindergarten student drew a smiley face saying, "I'm smiling. That means I'm happy." Overall, students' drawings corresponded with their verbal descriptions of feelings. As seen in Table 3, 63.6 % of the students drew pictures that portrayed similar feelings to those they reported verbally. However, for 36.3 % of the students, their drawings and verbal description did not communicate the same message. For example, a Grade 1 student who described her feelings as

Table 1

Students' (K-G2) Emotional Relationships with Mathematics

	K	G1	G2	Total
Positive	5	11	8	24 (70.5)
Negative	1	4	2	7 (20.5)
Mixed	1	0	2	3 (8.8)
NA	4	0	1	5
Total	11	15	13	39

Note: We excluded the number of students who did not complete the interview entirely or who did not answer the particular question (indicated as NA), when counting the percentage.

Table 2

Emotional Relationships with Mathematics Reflected in Students' Drawings

	K	G1	G2	Total
Positive	6	12	7	25 (75.7)
Negative	0	2	1	3 (9.0)
Mixed	0	0	1	1 (3.0)
Neutral	0	0	1	1 (3.0)
Non-Emotional	0	1	2	3 (9.0)
NA	5	0	1	6
Total	11	15	13	39

Table 3

Correspondence between Drawings and Interviews

	K	G1	G2	Total
Corresponding	4	10	7	21 (63.6)
Non-Corresponding	2	5	5	12 (36.3)
NA	5	0	1	6

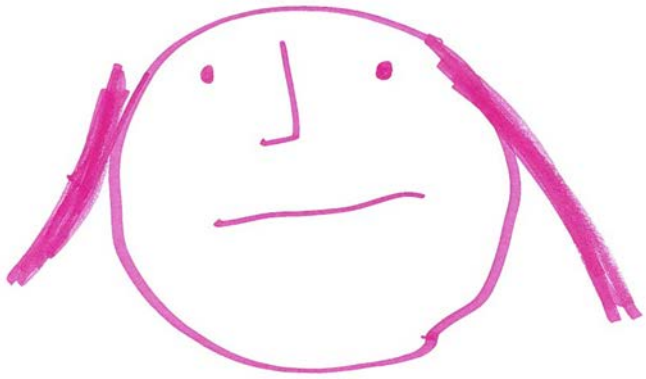

Figure 1. Face with a frown depicted by a Grade 1 student

"(I) have lots of fun" drew a picture that she depicted as "a face with a frown" (Figure 1). The following is the conversation between the interviewer and this student.

> Interviewer: Alright can you tell me about your picture? What's going on?
> Participant: I feel ... I have a frown.
> Interviewer: You have a frown? Why do you have a frown?
> Participant: That's because I don't like too much math.

As seen in this case, students' drawings and verbal descriptions sometimes communicated different emotional relationships with mathematics.

Many early years students described their feelings towards mathematics as "great," "happy," "fun," and "good." However, by the time students reached Grade 2, their feelings towards mathematics were not as uniformly positive. We noticed that many Grade 2 students described their feeling towards mathematics in relation to their perceived competence. Specifically, some Grade 2 student described their feelings as: "Pretty good, confident," "Um...confident," and "I feel like it's easy. Like, I don't need to worry about math" and some students articulated a desire for more challenge in mathematics. For example, a Grade 2 student said:

> I feel like happy and not happy, because I always wished there was three ranks. First rank, second rank, third rank. I always wished I was in the third rank so it could be harder for me so I could do that stuff.

In contrast, some early years students already showed the tendency to dislike challenges and complex mathematics problems and these students' relationships with mathematics were also bound up in their perceptions of their own competence. For example, another Grade 2 student described his feelings towards mathematics as "a little happy, a little frustrated" and told us that "it makes me feel a little frustrated and unhappy 'cause the math problems are really hard and I can't really figure them out." A Kindergarten student said mathematics was "sorta good and sorta bad. Bad because it's a lot of work. Good because if it's easy, I'll be done."

In addition to students who reported struggles with mathematics, some students reported a dislike for being interrupted by classmates in the mathematics classroom. For example, a student, in explaining her picture of a mathematics classroom (Figure 2), described her frustrations as follows.

> Interviewer: Okay. So what are these lines coming out of everybody's mouth?
> Participant: They're yelling.

Figure 2. Noisy classroom depicted by a Grade 1 student

Interviewer: They're yelling, okay. So you're the only one at your desk?
Participant: Yeah.
Interviewer: So how do you feel when all this talking and yelling [is happening] and people are out of their chairs?
Participant: I'm putting my arms up like this, going to cover my ears.
Interviewer: Okay, are you annoyed at the people?
Participant: Yeah, I put my pencil down and my eraser down so I wouldn't break that.

This student also said, "It's kinda hard to do my math ... because like people are interrupting." Already, at Grade 1, she recognized "smart students" and "non-smart students" and said, "I really hope the smarter people in my class are in my class next year, just because I don't want anyone asking me." Thus, her feeling towards mathematics was interrelated with how the classroom was set up, how she saw smartness in mathematics, and how she felt being "interrupted" by her classmates.

Some students told us about negative past experiences with mathematics, which shaped how they feel about mathematics now. A Grade 2 student said, "I don't really want to be at school when we're doing math." This student had had to move schools because of the ways in which he was learning mathematics at a particular elementary school were considered to be too hard for him. He said, "I got moved here and I lost a lot of good friends." This experience resulted in his negative relationship with mathematics.

Students' Commentaries on Mathematics Teaching

Given that some students' emotional relationships with mathematics seemed to have been shaped by the kind of classroom environment in which they were learning mathematics, in this section we consider the kinds of mathematics teaching that the students in early years education experienced. We focus in particular on mathematics teaching that students reported as fostering their positive relationships with mathematics, while being mindful of comments some students made about classroom distractions (as reported above).

While young students' commentaries about mathematics teaching were not extensive, some students did describe intriguing lessons that were centred on students' creativity, hands-on experiences, or role playing. In describing a favourite mathematics lesson, a student said, "Once in math the teachers said, 'How many ways can you add to ten?' So I thought of a bunch of ways." One of the lessons another student recalled with excitement seemed to relate to a role-playing activity involving money: "when you have a partner and somebody is the banker and somebody is the customer." He continued to describe the mathematical ideas (i.e., rounding up of numbers) involved in this particular "game." Another activity that was mentioned by a number of students (at one school) was the "double decker bus." One particular student talked about beads being used as passengers, which were then loaded onto the bus. The bus had 10 seats on the lower level and 10 on the upper and at various stops passengers got on or off the bus (necessitating adding and subtracting from a running total). In many of these scenarios, rather than being given a fixed set of questions to answer, students were allowed to pick numbers with which to work, and allowed some level of autonomy as the mathematical idea was acted out. The students' engagement could be heard not only in their descriptions of acting out the task with their classmates, but also in their descriptions of the mathematics involved in the activity.

Many students reported having an experience with numbers in everyday, out-of-school

contexts and some students mentioned that their teachers encouraged them to engage with mathematics in their daily lives. For example, in response to a question about whether students use mathematics every day, a student said, “My teacher always wants us to use math now.” This student described how he used addition to count everyday objects such as apples, blueberries, and towels. Similarly, other students also mentioned that they enjoyed solving mathematical problems set in contexts familiar to them, such as figuring out a relationship between the number of apples and the number of boxes required to pack them.

Some of the drawings early years students depicted communicated the collaborative nature of classroom mathematics learning (Figure 3). This is interesting because this kind of picture

Figure 3. Collaborative nature of classroom mathematics depicted by a Grade 1 student

illustrating the collaborative nature of learning was not observed among students in upper grades in the larger study.

Early years students' descriptions of mathematics teaching tended to focus on the strand of number sense and number operations. There were only a few who mentioned mathematics learning beyond the number strand. For example, the student who drew the picture of collaboratively building blocks with her classmates (see Figure 3) described how she enjoyed studying geometry. She noted that she, along with her classmates, built different geometric shapes using building blocks, identified the terms for the different shapes, and counted the number of particular shapes that they found. She also said that they had been asked to identify the number of blocks used to build a particular shape. Overall, the mathematical teaching that fostered positive feelings towards mathematics was described as embracing students' autonomy and creativity as well as embedding the element of playfulness.

Discussion

Early Years Students' Relationships with Mathematics

Our research concerns early years students' voices on learning mathematics, which has not been widely explored in the literature. Many students in our study described positive relationships with mathematics. As early as Grade 2, though, students associated their feelings towards mathematics with their competence. If they felt they were good at mathematics, their feelings towards mathematics were positive. While responses from Kindergarten and Grade 1 students were mostly positive, Grade 2 students' responses depicted more complicated relationships with mathematics, with some expressing negative emotions or mixed feelings towards mathematics. While some early years students wished for more challenge in mathematics, other students already felt confused and frustrated with school mathematics and rather wished easier problems. Some students were excited and happy with the classroom environment, while others were frustrated and suffered from distractions in the classroom.

Our research shows the significance of attending to the emotional aspects of learning mathematics in relation to the learning environment. Early years students' descriptions of memorable mathematics lessons suggested that mathematics teaching that utilizes embedded experiences (such as role play and games) and students' autonomy and creativity fostered positive feelings towards mathematics. In the literature, pedagogical suggestions and proposals have been made in order to enrich mathematics teaching in early years. For instance, in publications directed towards early years educators in Alberta, McGarvey (2009) provides concrete instructional strategies to foster children's understanding of algebraic relationships during early childhood and Sterenberg (2008) suggests using children's literature to foster students' early numeracy, while connecting it with their everyday experiences. Also, by building on children's informal mathematical knowledge, teachers can facilitate development of a wide range of mathematics for young children (Ginsburg & Seo, 1999). Our findings add to this body of literature by emphasizing the importance of promoting students' autonomy and creativity in fostering their positive relationships with mathematics.

Methodological Issues

Given that the study of early years students' relationships with mathematics is an emerging

field, we can also offer some insights into the challenges of gathering meaningful data with this population regarding this topic. We noted in our interviews that some of the youngest (Kindergarten) students, while being familiar with concepts that knowledgeable adults would recognise as mathematical (such as sorting, patterning, counting, shape recognition, etc.), did not know the word "mathematics" and had not begun the conceptual process of clustering these concepts and ideas as related to one another and to the discipline of mathematics. We raise this issue not to insist that Kindergarten teachers be deliberate about "segmenting the world" in this way, but to raise awareness that there is a deliberate choice to be made in this respect by Kindergarten teachers in the way they introduce and talk about mathematical concepts and that discussion of the advantages and disadvantages of associating these concepts with mathematics should be an important dimension of early years teacher education programs.

We also noted that when students did not know the word "mathematics" it was difficult to ask meaningful interview questions about the nature of mathematics without leading their responses (by, for example, asking them whether, in their classrooms, they did any counting or made patterns and so forth). We found that asking students to draw and then describe their entire classrooms and talk about what they did there often surfaced relevant themes and concepts that we could then ask more about, though this tended to take quite a lot of time and much of the material generated was not of direct relevance to the research topic. Additional methodological advice from others who have encountered this issue would be a welcome addition to the mathematics education literature.

A reviewer of our manuscript raised a concern about the methodological value of posing a stark question to young children (i.e., "What is mathematics?") and wondered whether asking students to complete a simile (If math were an animal it would be _____ because _____) might have been more productive. We do agree that even when students knew the word "mathematics" it was difficult to enquire about their knowledge of the nature and boundaries of the discipline without leading their responses. We decided to include, early in each interview, a fairly stark question about what mathematics is in order to gain, as best as we could, a sense of what students knew about the word and its meaning. Then, informed by the methodological framework of narrative inquiry, we followed up with many additional questions and prompts to give context to our line of questioning and to give students many different opportunities to reveal their thinking. Hence, in addition to asking directly what students thought mathematics was, we asked them to draw pictures relating to mathematics (as described in this article), we asked about where students encountered mathematics (hence inviting a potentially broader interpretation of what mathematics is), we asked about their earliest memories that had something to do with mathematics, we asked about whether they had heard or seen mathematics portrayed in the media (on television, in movies, books), we asked about their parents' and siblings' use of and relationships with mathematics, and we asked students to complete the sentence "Learning mathematics is like ... " (though most younger students did not seem to understand simile and after the first few interviewees' attempts to respond to this prompt we typically did not ask the early years students to complete this task). Despite these many and varied opportunities to describe mathematics, we still found that most students (from Kindergarten to Grade 12, not just early years students) limited their description of mathematics to number and operations. Again, the literature would benefit from enhanced discussion of methodological techniques that are useful with very young children when enquiring about the nature and scope of mathematics.

Educational Implications

Our study paints a picture of early mathematics learning environments that are, overall, positive, exciting, and enjoyable. This finding is particularly significant in highlighting the pedagogical efforts made by teachers of the early years students in fostering positive relationships with mathematics among students at this critical time in their development. We think that it is important to emphasize this finding, given that previous studies reported in the literature have tended to focus on early childhood educators' deficiencies, including their lack of mathematical knowledge and confidence (e.g., Sarama & Clements, 2009; Ginsburg et al., 2008). Although awareness of such deficiencies is important to further advance pedagogical and professional development, our findings with Alberta students affirm children's positive mathematics experiences in the early years and provide a reason to be hopeful about these children's later mathematics development. As our wider data suggest, though, the proportion of students who have a positive relationship with mathematics diminishes throughout their years of schooling, a finding that is consistent with previous studies (Hall, 2013; Lubienski, Robinson, Crane, & Ganley, 2013; Lupart, Cannon, & Telfer, 2004), and we are therefore troubled by our finding that students as young as Grade 2 are already linking perceived mathematics competence with feelings about mathematics. Given that research has established links between students' beliefs about mathematics and their achievement levels (e.g., Anderson, et al., 2006), this finding raises a number of questions that warrant further investigation. In particular, further research might examine the relationship between the content of the early years curriculum in Alberta, with its heavy emphasis on number and computation, and students' feelings about mathematics. In addition, it would be worthwhile to examine whether there are shifts in pedagogical practices for mathematics from Kindergarten to the later elementary years (for example, a reduction in games/play and/or less autonomy and creativity for students) that may be contributing to students' worsening attitudes to mathematics as they move through the grades.

Given our findings that, overall, the youngest children in our school system enjoy and appreciate mathematics, a major imperative for all educators should be to find ways to preserve and enhance these young children's positive relationships with mathematics so that a greater proportion of students retain a healthy relationship with mathematics throughout schooling and throughout their lives. At the same time, our findings also suggest the significance of identifying and attending to the needs of some students in early years education who have already developed negative relationships with mathematics.

Acknowledgements

This research was supported by the Social Sciences and Humanities Research Council of Canada. Any opinions, findings, and conclusions expressed herein are our own and do not necessarily reflect the views of the funding agency.

We would like to thank all the students who participated in this study. We also would like to thank Dr. Jennifer Hall and Dr. Lyndon Martin for their support in the process of conducting this study.

References

Ahmed, W., Minnaert, A., Kuyper, H., & van der Werf, G. (2012). Reciprocal relationships between math self-concept and math anxiety. *Learning and Individual Differences, 22*(3), 385-389. doi: 10.1016/j.lindif.2011.12.004

Anderson, J. O., Rogers, W. T., Klinger, D. A., Ungerleider, C., Glickman, V., & Anderson, B. (2006). Student and school correlates of mathematics achievement: Models of school performance based on pan-Canadian student assessment. *Canadian Journal of Education, 29*(3), 706-730.

Ashby, F. G., & Isen, A. M. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*(3), 529-550. doi: 10.1037/0033-295X.106.3.529

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General, 130*(2), 224-237. doi: 10.1037/0096-3445.130.2.224

Charlesworth, R., & Leali, S. A. (2012). Using problem solving to assess young children's mathematics knowledge. *Early Childhood Education Journal, 39*(6), 373-382.

Chase, S. E. (2005). Narrative inquiry: Multiple lenses, approaches, voices. In Norman K. Denzin & Yvonna S. Lincoln (Eds.), *The handbook of qualitative research* (3rd ed., pp. 651-679). Thousand Oaks, CA: Sage.

Clandinin, D. J., & Rosiek, J. (2007). Mapping a landscape of narrative inquiry: Borderland spaces and tensions. In D. J. Clandinin (Ed.), *Handbook of narrative inquiry: Mapping a methodology* (pp. 35-75). Thousand Oaks, CA: Sage.

Clements, D. H., & Sarama, J. A. (2014). *Learning and teaching early math: The learning trajectories approach* (2nd ed.). New York, NY: Routledge.

Di Martino, P., & Zan, R. (2010). 'Me and maths': Towards a definition of attitude grounded on students' narratives. *Journal of Mathematics Teacher Education, 13*(1), 27-48. doi: 10.1007/s10857-009-9134-z

Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: A bridge between beliefs and emotions. *ZDM, 43*(4), 471-482. doi: 10.1007/s11858-011-0309-6

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Brooks-Gunn, J. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428-1446.

Ginsburg, H. P., Inoue, N., & Seo, K. H. (1999). Young children doing mathematics: Observations of everyday activities. In J. V. Copley (Ed.), *Mathematics in the early years* (pp. 88-99). Washington, DC: National Association for the Education of Young Children.

Ginsburg, H. P., Lee, J. S., & Boyd, J. S. (2008). Mathematics education for young children: What it is and how to promote it. *Social Policy Report, 22*(1), 1-11, 14-23.

Ginsburg, H. P., & Seo, K.-H. (1999). Mathematics in children's thinking. *Mathematical Thinking and Learning, 1*(2), 113-129. doi: 10.1207/s15327833mtl0102_2

Hall, J. (2013). *Societal views of mathematics and mathematicians and their influence on elementary students* (Unpublished doctoral dissertation). University of Ottawa, Ottawa, Canada.

Hall, J., & Towers, J. (2014). Tracing student experience using mathematics autobiographies. In S. Oesterle, C. Nicol, P. Liljedahl, & D. Allan (Eds.), *Proceedings of the joint meeting of the 38th annual meeting of the International Group for the Psychology of Mathematics Education and the 36th annual meeting of the North American Chapter of the Psychology of Mathematics Education*, Vol. 6 (p. 91). Vancouver, BC: PME.

Hall, J., Towers, J., Takeuchi, M., & Martin, L. C. (2015). Investigating students' positive relationships with mathematics. In Beswick, K., Muir, T., & Wells, J. (Eds.), *Proceedings of the 39th annual meeting of the International Group for the Psychology of Mathematics Education* (Vol. 1, p. 164). Hobart, Tasmania: PME.

Jordan, N. C., Kaplan, D., Ramineni, C., & Locuniak, M. N. (2009). Early math matters: Kindergarten number competence and later mathematics outcomes. *Developmental Psychology, 45*(3), 850-867.

Josselson, R. (2006). Narrative research and the challenge of accumulating knowledge. *Narrative Inquiry, 16*(1), 3-10.

Larkin, K., & Jorgensen, R. (2015). 'I hate maths: Why do we need to do maths?' Using iPad video diaries to investigate attitudes and emotions towards mathematics in Year 3 and Year 6 students. *International Journal of Science and Mathematics Education*, 1-20. doi: 10.1007/s10763-015-9621-x

Lubienski, S. T., Robinson, J. P., Crane, C. C., & Ganley, C. M. (2013). Girls' and boys' mathematics achievement, affect, and experiences: Findings from ECLS-K. *Journal for Research in Mathematics Education, 44*(4), 634-645.

Lupart, J. L., Cannon, E., & Telfer, J.-A. (2004). Gender differences in adolescent academic achievement, interests, values, and life-role expectations. *High Ability Studies, 15*(1), 25-42. doi: 10.1080/1359813042000225320

McDonough, A., & Sullivan, P. (2014). Seeking insights into young children's beliefs about mathematics and learning. *Educational Studies in Mathematics, 87*(3), 279-296. doi: 10.1007/s10649-014-9565-z

McGarvey, L. (2009). Algebraic reasoning in early grades. *Early Childhood Education, 38*(2), 3-7.

Rader, N., & Hughes, E. (2005). The influence of affective state on the performance of a block design task in 6-and 7-year-old children. *Cognition & Emotion, 19*(1), 143-150. doi: 10.1080/02699930441000049

Riessman, C. (1993). *Narrative analysis*. Newbury Park, CA: Sage.

Sarama, J. A., & Clements, D. H. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. Florence, KY: Routledge.

Sterenberg, G. (2008). Counting on stories to develop early numeracy. *Early Childhood Education, 38*(1), 15-18.

Towers, J., Takeuchi, M., Hall, J., Martin, L. (2015). Exploring the culture of school mathematics through students' images of mathematics. In T. G. Bartell, K. N. Bieda, R.T. Putnam, K. Bradfield, H. Dominguez (Eds.), *Proceedings of the 37th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 570-574). East Lansing, MI: Michigan State University.

Towers, J., Takeuchi, M., Hall, J., & Martin, L. (2016). Students' emotional experiences learning mathematics in Canadian schools. Chapter submitted for publication in U. Xolocotzin (Ed.), *Understanding emotions in mathematical thinking and learning*. Waltham, MA: Elsevier Academic Press.

van Oers, B. (2010). Emergent mathematical thinking in the context of play. *Educational Studies in Mathematics, 74*(1), 23-37.

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science, 23*(5), 492-501. doi: 10.1177/0956797611429134

Zan, R., Brown, L., Evans, J., & Hannula, M. S. (2006). Affect in mathematics education: An introduction. *Educational Studies in Mathematics, 63*(2), 113-121. doi: 10.1007/s10649-006-9028-2

Dr. Miwa Aoki Takeuchi is an Adjunct Assistant Professor and a Postdoctoral Scholar at the Werklund School of Education, University of Calgary.

Dr. Jo Towers is Werklund Research Professor at the Werklund School of Education, University of Calgary.

Ms. Jennifer Plosz is a Master of Science student at the Werklund School of Education, University of Calgary.