Symposium: Research Methods Involving Children's Drawings in Mathematical Contexts

In this symposium we present and discuss some methodological issues and possible solutions that have been encountered during our research into children's mathematical thinking, behaviours and affective responses, as reflected, at least in part, through their drawings. It has been claimed that, "Drawing can be a window into the mind of a child" (Wolek, 2001, p. 215). Such a statement implies that a child's self-created drawing can provide an indication of his/her internalised mathematical perceptions and conceptions. Note that the word 'drawing' can be used as either a noun or a verb, and hence can refer to either a completed artefact or to the dynamic act of creation. Depending on the aims, theoretical perspective and context of the study, researchers may focus on one form of 'drawing' or explore both forms.

Although drawing has long been an expected component of children's mathematical activity, rigorous research methods utilising mathematical drawings have remained somewhat underdeveloped. In recent years, a number of researchers have grappled with the design and development of specific aspects of methodology in their separate projects. With few established research methods for guidance, researchers have been creating and refining task designs, interview protocols, data capturing strategies, analysis techniques and interpretation processes for their studies of children's mathematical drawing. Each of the symposium papers presents a different research tool or technique that has been developed within its own unique context, with the purpose of stimulating discussion and advancing the development of effective research methods in the field of children's mathematical drawing.

Wolek, K. (2001). Listen to their pictures: An investigation of children's mathematical drawings. In Cuoco, A. (Ed.), *The roles of representations in school mathematics*, NCTM 2001 Yearbook, (pp. 215-227). Reston VA: NCTM.

Chair/Discussant: Joanne Mulligan

Paper 1: Amy MacDonald & Steven Murphy *Using the drawing-telling approach to reveal young children's mathematical knowledge.*

Paper 2: Jennifer Way & Jennifer Thom. *Capturing the mathematical drawing process using a digital pen.*

Paper 3: Kate Quane, Mohan Chinnappan & Sven Trenholm. *The nature of young children's attitudes towards Mathematics.*

Paper 4: Jill Cheeseman & Andrea McDonough. *Coding young learners' pictorial responses to an open-ended assessment task.*

2019. In G. Hine, S. Blackley, & A. Cooke (Eds.). Mathematics Education Research: Impacting Practice *(Proceedings of the 42nd annual conference of the Mathematics Education Research Group of Australasia)* pp. 99-116. Perth: MERGA.

The Nature of Young Children's Attitudes towards Mathematics

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This paper contributes to the Symposium: Research methods involving children's drawings in mathematical contexts by providing insight into young children's attitudes towards mathematics through the use of drawings. Children in Years 2 and 3 (n=25) participated in this study which aimed to identify a range of attitudes towards mathematics using the Three-dimensional Model of Attitude (Zan & Di Martino, 2007). The analyses illustrate drawings in conjunction with written responses, interviews and classroom observations offers authentic evidence of young children's attitudes towards mathematics. Further, findings indicate that children's Vision of Mathematics contributes significantly to their overall attitude.

The link between attitudes towards mathematics and achievement has been of considerable interest, as findings suggest negative student attitudes towards mathematics have a detrimental impact on their memory and achievement (Zan & Di Martino, 2007). However, the construct of attitude is nebulous and multi-dimensional (Di Martino & Zan, 2010; Hannula, 2002; Leder, 1987).

Traditionally, attitudes towards mathematics have been defined via the dichotomy of liking or disliking mathematics. While this simplistic view places emphasis on the emotional element of attitude, it fails to address the dynamic nature of attitude and how attitude influences, and impacts on behaviour (Ajisuksmo & Saputri, 2017). Further, such a narrow definition ignores the critical role of beliefs and values which may enact or inhibit behaviours influencing student learning (Goldin, Epstein, Schorr, & Warner, 2011; Skott, 2015).

In order to address this issue, Zan and Di Martino (2007) have conceptualised attitude towards mathematics in terms of three dimensions incorporating emotions, values and beliefs. The Three-dimensional Model of Attitude (TMA) comprises of the Emotional Dimension (ED; emotional responses to mathematics), Vision of Mathematics (VM; instrumental versus relational view, values and appreciation of the subject) and Perceived Competence (PC; perceived ability and self-concept). This model broadens the definition of attitude and has been successfully used in autobiographical research with older students (Di Martino & Zan, 2010). However, there is a paucity of research into affective aspects of mathematical learning and young children's attitudes towards mathematics (Grootenboer, Lomas & Ingram, 2008). The overall aim of our larger study is to address the issue by examining attitude via children's drawings. In this paper, we report phase one of the study.

Drawings as a data source for attitude

Children's drawings are the primary methodological tool for this research. Drawings provide a rich source of data that can convey subtle and multifaceted expressions of feelings and ideas that reflect children's understandings of real-world mathematical experiences (Cherney et al., 2006; Jolley, Fenn, & Jones, et al., 2004). Drawings are also an easy vehicle for communication, allowing children to express what is important to them. The review conducted to date indicates attitudes are voluntarily presented in children's drawings showing the complexity of children's attitudes, beliefs and values towards mathematics.

Method

This exploratory study was conducted in a South Australian State primary school. Four data collection techniques were used; drawings, written responses, interviews and classroom observations, providing both non-lesson and lesson contexts to gather data about children's attitudes towards mathematics. Twenty-five children were provided with 24 coloured textas, an A3 piece of paper and asked to draw themselves doing mathematics and write about their drawing. Each drawing was then labelled with a code indicating class, gender and age.

A prompt was read to the children followed by a series of question in a 10-15 minute semi-structured interview session Interview questions were designed to clarify what children had drawn and to help ascertain children's ED, VM and PC. For example: 'If mathematics was a food what food would it be and why?' Finally, classroom observations were conducted with a subset of children to examine how children's attitudes, depicted in their drawings, may be enacted during their mathematical learning experiences.

Code Development

Data were analysed using the TMA framework. The analysis involved deductive, anticipatory and inductive methods. A deductive approach was used to develop the main ideas and indicators using existing frameworks for analysing children's drawings, drawing upon the fields of mathematics and science education, education, and psychology. A rubric was then developed with the addition of two sub-dimensions for each dimension, with each sub-dimension measured on a scale from 0, ('cannot be categorised'), to 5, ('extremely positive'). Some indicators were anticipated, stemming from the researchers' own experience as a teacher. For example, the sub-dimension 'overall appearance' uses the anticipatory response 'messy hair' as an indicator. Additionally, an inductive approach was employed to analyse the children's drawings and determine the suitability of the categories.

Drawings were systematically analysed using the principles of atomism and holism. The six scores for each sub-dimension were then added to give an overall score out of 30. Taken together, this process provided a quantitative measure of a child's overall attitude towards mathematics, with intervals classified according to Table 1.

Table 1:
Interval Classifications for Attitudes towards Mathematics

Interval	Attitude Classification
< 5	Excluded from analysis
6 – 10	Extremely Negative
11 – 15	Negative
16 – 20	Neutral
21 – 25	Positive
26 – 30	Extremely Positive

Findings

A range of attitudes were identified in the 25 children. No child was classified as having an Extremely Negative attitude. One child (A10) was classified as having a negative attitude towards mathematics. To help illustrate the outcome of the analysis, her participation will now be discussed in more detail. At first, the drawing (Figure 1) suggested A10 enjoyed mathematics. However, asking the child to explain her drawing revealed the child felt a range of negative emotions including frustration, worry and animosity towards mathematics.

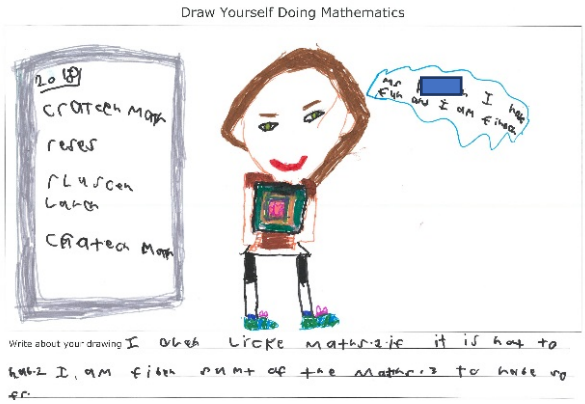

Figure 1: Drawing and written response from a child with a negative attitude
(Yr 3, F, 8 Years ED = 5, VM = 3, PC = 3)

The excerpt below identifies a specific instance where her frustration was revealed.

A10: I like creating things a lot and I'm, well if I do too much maths, I don't enjoy it and also um if sometimes I find it easy and sometimes, I find it hard and if I find it hard, I start to hate it.

Interviewer: What do you find hard?

A10: Like if I don't know what that is, I don't really like it and I get really frustrating (sic) and then I get a headache.

Interviewer: Can you give me an example of when that happens?

A10: Like um if I don't know what a tens frame is which happened, and then I got really frustrated and I was worried that I got it wrong and Ms Teacher (edited for confidentiality reasons) looked at the rest of my work and then I started to get really frustrated.

In the case of A10, she could articulate a particular instance regarding not understanding a mathematical term that made her feel frustrated and worried, resulting in an animosity towards mathematics. Using gentle probing questions, the interview provided further insights into the child's attitude. The child proposed a schedule for learning mathematics that involved creative mathematics as she enjoys creating things. An example of this is the child's t-shirt which she described as an animal catcher that can catch insects. A10 was asked why she was smiling in her drawing. She responded with "because um I wanted to be in my relaxing time, I wanted to create a fun animal catcher." Relaxing time in this instance is the child's way of removing herself from reality. A10 articulated few mathematical concepts, reflecting an instrumental understanding of concepts.

When asked to rate herself as a maths student, she rated herself zero out of ten "because I am terrible at maths and it's too hard, cause sometimes I'm nearly in tears". The child's written statement below her drawing verifies how the child feels about mathematics. The child has written "I don't like maths. If it is not too hard. I am feeling some of the maths too hard, so frustrated." This is evidence of how the child is trying to make a statement regarding the perceived difficulty of the subject. It appears that the child is uncomfortable when challenged by cognitively demanding tasks. The child's written response contributes to all three dimensions of TMA. That is, emotionally she is feeling frustrated, is not liking the subject (ED) and her statement about the difficulty of mathematics provides an indication of her VM. Overall the statement contributes to understanding her negative self-concept (PC).

Child A10 was observed three times during class with the child partaking in maths rotations involved game-based tasks on telling the time and place value. Other lessons involved individual problem-solving using the four operations and an outdoor experience to collect data about animals in a natural habitat. During the observations negative talk and task

avoidance were evident, including asking the teacher what jobs she could do, trying to find a particular coloured pencil and stating “I can’t do this”, “this is too hard” and “I don’t get it”. The child’s body language was observed providing further evidence of her feelings towards mathematics, including walking away from a task, shrugging shoulders and clenched lips. A10 appeared to be more engaged and willing to participate in the outdoor experience which had a science focus to the data collection. Altogether, drawings, written and interview responses provide a rich, relatively complete picture of A10’s attitude towards mathematics reflecting the authentic personal experience of the child.

Conclusion

Phase 1 of the study reported here, shows children’s drawings in conjunction with interviews and observations provide an effective means of ascertaining young children’s attitudes towards mathematics. Children were able to depict themselves doing mathematics and articulate their emotions, VM and PC. Children generalised a range of personal experiences having control over what they wanted to draw. A full range of attitudes towards mathematics were identified. Thus, drawings provided children with the tool to share not only their feelings about mathematics, but allowed insight into their values and beliefs about themselves doing mathematics. This paper reports a single child’s negative view of mathematics. A larger sample may find greater insights into children’s attitudes towards mathematics, in particular, alternative negative attitudes. Applying TMA to the four data types has been a challenge as a child’s response can be evidence for several sub-domains, indicating that the dimensions may overlap. The relationship between the three dimensions is currently being explored.

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