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Rainbows, Presents, Zombies, and Frankenstein's Monster: Insights into Young Children's Attitudes towards Mathematics

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Abstract

Understanding young children's attitudes towards mathematics provides insights into their lived mathematical experiences. It has long been recognized that attitudes towards mathematics have a profound influence on mathematical achievement. Despite the considerable amount of research into students' attitudes toward mathematics, limited research has been conducted into *young children's* attitudes toward mathematics. Using the modified Three-dimensional Model of Attitude affords the opportunity to describe children's attitudes more comprehensively, moving beyond the emotional dichotomy. This paper reports research conducted with Australian children aged between seven and eight years of age (N=106) using children's drawings, written descriptions, and interview responses. The three data sources resulted in rich narratives providing young children with multiple opportunities to voice what is important to them and their learning. Analysis indicated a range of attitudes, including negative attitudes towards mathematics. Further, a child who has a narrow vision of mathematics impacts their overall Attitude towards the subject.

Introduction

Early education that provides a strong foundation is critical to children's future participation and success in mathematics (Duncan et al., 2008). Understanding children's attitudes towards mathematics provides insights into their lived mathematical experience and participation (Pepin, 2011). Despite the considerable amount of research into students' attitudes toward mathematics, limited research has been conducted into *young children's* attitudes towards mathematics (YCATM) (Ingram et al., 2020).

This paper describes the results of a project that used "specifically designed instruments" to "infer aspects of affect" as recommended by Attard et al. (2016, p. 89). The research reported in this paper comes from a multistage research project that investigated the range and nature of YCATM in a non-lesson context (children's drawings, written descriptions and interview responses) and lesson-context. This paper reports on the findings from the *non-lesson context*. In doing so, answering the broad research question: 'What is the range and nature of young children's attitudes towards mathematics, in a non-lesson context?

Attitudes towards Mathematics

Attitude is a multi-dimensional construct (Quane, 2021; Walker et al., 2020; Zan et al., 2006) that can be complex to unpack. Researchers agree that the attitude construct consists of affective, behavioural and cognitive components (DeBellis (DeBellis & Goldin, 2006; McLeod, 1989; Quane et al., 2021; Rokeach, 1968; Walker et al., 2020), and as such any framework that is used to analyzed attitudes towards mathematics needs to capture this multi-dimensionality. While there is consensus about these three components, there is debate about the composition of each component. For example, DeBellis and Goldin (2006) posit that "values/morals/ethics" is a separate dimension (p. 135), while several researchers argue that dispositions, confidence, motivation, self-efficacy, and self-concept are components of the affective dimension of Attitude (Leder & Grootenboer, 2005; Tuohilampi et al., 2016). The current debate demonstrates the complexity of defining the construct' attitudes towards mathematics'. This debate recognizes that there is a fundamental shift from the traditional dichotomies such as liking or disliking mathematics (Capps & Cox, 1969) or Attitude only being positive or negative (Lipnevich et al., 2013) to a multi-dimensional approach.

The corpus of literature informs us that attitudes are acquired from social and school experience and others (Aiken (Aiken, 1972; LaPiere, 1934; Quane, 2021). It is also widely recognized that attitudes have a profound influence on learning, retention of and achievement in mathematics (Berger et al., 2020; Hemmings & Kay, 2010; Ma, 1997). Grootenboer (2001) describes the connection between attitudes as potentially debilitating in learning mathematics. Thus, it is necessary to understand attitudinal factors and how they influence attitudes towards mathematics. Such an understanding would provide valuable insight into understanding student achievement in mathematics (Hannula et al., 2016). However, these findings are true for upper primary, secondary, and tertiary students. An area of research that has been surprisingly overlook is examining YCATM (Ingram et al., 2020).

The limited research exploring YCATM may be attributed to the research methods available that can be used with young children. Further, any research method employed to ascertain attitudes towards mathematics needs to disentangle the different dimensions of this complexity. That is, the use of children's drawings as a research tool needs to be sensitive to the multi-faceted nature of the construct in question, namely Attitude. Additionally, data about attitudes towards mathematics has to capture the dynamic interplay between the dimensions of attitudes (Quane et al., 2021).

Interpreting Children's Drawings to Ascertain Their Attitude towards Mathematics.

Children's drawings act as a list or "graphical narration" about what a child is portraying (Vygotsky, 2004, p. 77). Drawings are a vehicle for children to make and communicate meaning. They are a tangible record of students' experiences and perceptions, providing a method for children to express themselves (Bland, 2018; Walker, 2007). The use of participants' drawings has several affordances and have been effective to ascertain affective dimensions (Crawford et al., 2012; McDonough & Ferguson, 2014; Picker & Berry, 2000, 2001).Whilst there have been over two decades of research using children's drawings to determine affective aspects in mathematics these studies have emerged from the "draw a scientist" protocol (See Chambers, 1983; Farland-Smith, 2012; Finson et al., 1995;

Huber & Burton, 1995).

In terms of children's Emotional Dimension, Yuen (2004) claims emotions revealed by children through the act of drawing may not otherwise have been identified or discussed. In constructing a drawing, a child has the freedom to depict what they want and how they want. In producing a drawing, children may use principles of deviation or image metaphors. The concept of "deviation" is central to the act of drawing. Lowenfeld Lowenfeld and Brittam (1964, p. 143) describe deviation as exaggeration, omissions and change of representations that children use in their drawings. These three principles pertain to the size and shape of an object.

It is important to note how an observer views the three principles. Lowenfeld and Brittam (1964) cautioned the observer of a drawing regarding making incorrect judgments about a child's intention of using disproportional elements within a drawing. Correct judgements and interpretations are made by asking the child about their drawing to understand the reasons for using disproportionality or drawing a particular object. When children have used the three types of deviations, they have drawn what is real, important, and actual to them (Lowenfeld & Brittam, 1964).

In producing a drawing, children may also provide several layers of meaning to a particular element or to the entire drawing. Children may create a symbolic representation to represent something else or make comparisons. In doing so, creating an image metaphor that children may use to convey aspects of their Attitude towards mathematics.

Lakoff (1987) defined an image metaphor as "map[ing] conventional mental images onto other conventional mental images" (pp. 219-220). For example, in one of the cases presented, a child has drawn Frankenstein's Monster. We can visualize Frankenstein's Monster, his stature, face, and some of his characteristics.

The use of an iconic figure such as Frankenstein's Monster immediately conjures up images of monstrous experiences and hideous creatures. However, this image of Frankenstein's monster is an image and not yet an image metaphor. For this image to become an image metaphor, a second image is required or as Lakoff (1987) describes: "image metaphors only occur when there is both a source image and a target image that the source image maps onto" (p. 222). Revisiting the image of the Frankenstein's Monster we have a source image. Adding a second image of a person feeling 'disgusting' and 'stupid' when doing mathematics, with the added pressure of quickly doing mathematics forms an image metaphor. Interpreting children's drawings and the meaning behind a drawing is multi-faceted requiring multi-level analyses (Quane et al., 2021). The process for analyzing children's drawings as a starting point to ascertain their attitudes towards mathematics is now described.

Theoretical Framework

Children's drawings acted as the incipient point of data collection and these artefacts, along with written descriptions, interview responses and observations of mathematical learning experiences were analyzed using the Modified Three-dimensional Model of Attitude (MTMA). The MTMA builds on the work of (Di Martino & Zan, 2010, 2011) who developed the three-dimensional model of Attitude out of "necessity" (p. 157). Di Martino and Zan (2011) theorized that Attitude towards mathematics comprises of three interconnected dimensions: Emotional Dispositions (ED), Vision of Mathematics (VM), and Perceived Competence (PC). The model was developed by examining adolescents' autobiographical essays and has several iterations including single direction arrows to bidirectional arrows to depict three interconnected dimensions. Zan and Di Martino (2007) describe the three dimensions as:

- the Emotional Disposition expressed as "I like/dislike Mathematics"
- vision of mathematics dimension expressed as "Mathematics is…" and
- students' perceived competence dimension of "being/not being able to succeed in mathematics," expressed as "I can/can't do it."

The TMA does not take into consideration the development of attitude within the child as reported by Di Martino (2019)when investigating young children's attitudes towards mathematical problem solving. This may be due to the original use of TMA to analyze adolescents' autobiographical essays. The TMA could be extended to cater for the developmental nature of attitude, which would then provide a suitable framework to investigate YCTAM.

Extending the framework would provide an opportunity to listen to students' voices, the importance of which Di Martino and Zan (2010) acknowledged: "our study made us convinced of how important it is to let these voices talk" (Di Martino & Zan, 2010). With this acknowledgement, Di Martino (2019) puts forward the need for "the development of new methods to collect data" to investigate young students' attitudes towards mathematics and problem-solving (p. 305). The modification to TMA used as the theoretical framework of this research recognizes that attitudes are nuances and change as a person develops. Further, the modifications encapsulate a more nuanced view of attitudes by sub-dividing each broad dimension of TMA into two new sub-dimensions. Figure 1 depicts the MTMA.

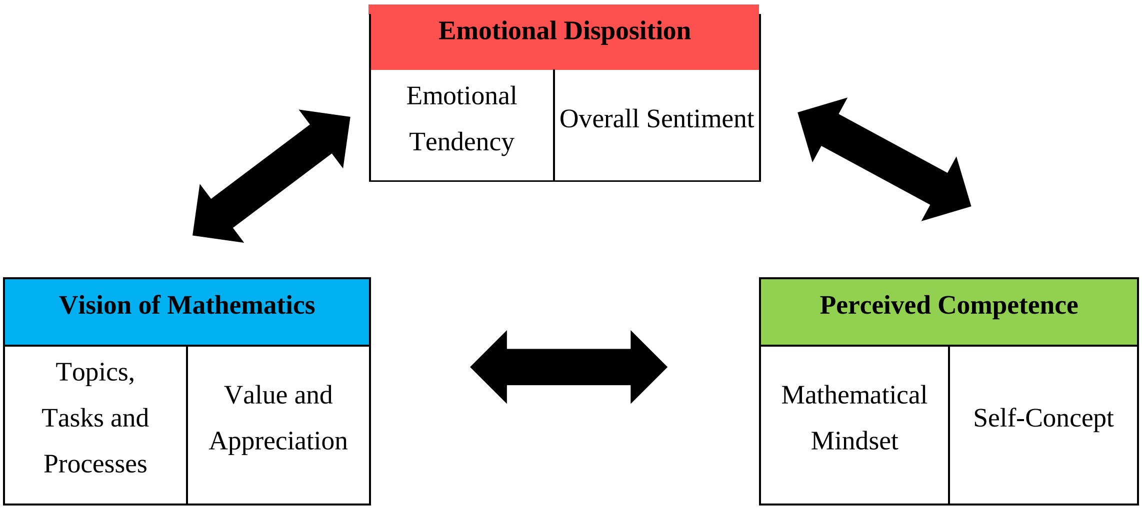


Figure 1. Modified TMA (Original Model by Di Martino & Zan, 2011; Modified by Quane et al. (2021)

The six sub-dimensions added clarity for each TMA dimension. A brief description of the six sub-dimensions of MTMA is provided in Table 1.

Table 1. Description of the Modified TMA Sub-Dimensions

Dimension	Sub-dimension	Description
Emotional Disposition	Emotional Tendency	Children's feelings and emotional responses experienced during mathematical activity and tasks
	Overall Sentiment	Children's general reactions and emotional beliefs regarding mathematics, including non-verbal cues (posture, gestures and body language) and verbal cues
Vision of Mathematics	Tasks, Topics, and Processes	Types of mathematical learning experiences and processes identified by children; the number of mathematical topics and how children communicate their mathematical understanding and learning
	Value and Appreciation	How and what children view as important and acknowledge as worthwhile about mathematics
Perceived Competence	Mathematical Mindset	Children's perceptions of themselves related to their ability to do mathematics
	Self-Concept	Children's beliefs in their mathematical ability and their expectancy for success.

Source: Quane et al. (2021)

Participants

A total of 106 children from three South Australian schools participated in the study. Participants were aged between seven and nine years with 73 children (69%) enrolled in Year 2 and 33 children (31%) in Year 3. A mix of male (n=58, 55%) and female (n=48, 45%) children, including children from diverse language, cultural and geographical backgrounds participated in the study.

Table 2. Participant Demographics and Numbers

School	School Sector	Class	Year Level(s)	Male	Female	% of class population [b]
A	Government, inner regional with total enrolment of 285[a] students *n = 25*	1	2/3	1 (Yr 2) 4 (Yr 3)	2 (Yr 2) 4 (Yr 3)	11/24 (46%)
		2	3/4	3	4	Yr 3: 7/11 (64%)
		3	1/2	3	4	Yr 2: 7/18 (39%)
B	Government, major city with total enrolment of 861[a] students n = 58	4	1/2	8	5	13/24 (54%)
		5	2	13	10	23/25 (92%)
		6	2	2	3	5/25 (20%)
		7	1/2	5	3	8/25 (32%)
		8	3	3	6	9/26 (35%)

School	School Sector	Class	Year Level(s)	Male	Female	% of class population [b]
C	Government, inner regional with total enrolment of 163[a] students n = 23	9	2/3	7 (Yr 2) 1 (Yr 3)	4 (Yr 2) 2 (Yr 3)	14/24 (58%)
		10	2/3	4 (Yr 2) 2 (Yr 3)	0 (Yr 2) 3 (Yr 3)	9/25 (36%)
Total	**3 schools**	**10**		**56**	**50**	**106/227 (47%)**

[a] Total Enrolment is Taken from myschool Website. [b] Percentage rounded to the nearest whole number.

Methodology

A mixed-methods approach was used to gain multiple perspectives about the range and nature of YCATM. Cohen et al. (2018) posit that mixed-methods research "enables rich data to be gathered which afford the triangulation that has been advocated in research" (p. 26) and which is a key feature of this present research. Within the mixed-methods design, the research was both exploratory and descriptive. The broad lens applied to the research is the exploratory element to understand the nature and range of YCATM in a non-lesson context. Further, the research is descriptive in nature. As the name suggests, descriptive research highlights the existence and extent of an issue (de Vaus, 2014). This research aimed to accurately and systematically describe YCATM in a non-lesson context, where children were withdrawn from class to complete a drawing of themselves doing mathematics, provide a written response and participate in an interview.

The research employed three different research techniques for data generation, examining YCATM to identify and describe possible relationships between the two contexts. The first two research techniques used children's drawings and asking children to write about what they have drawn. The third technique used a semi-structured interview so children could explain and clarify elements within their drawings and reduce any potential misinterpretation. The interview also provided the ortunity to ask question to provide further insights into YCATM. These questions include:

- If mathematics was food, what food would it be and why? (Frid, 2001)
- What is maths (mathematics)?
- How would you rate yourself as a maths (mathematics) student?

Quantitative analysis has been conducted to provide simple numerical summaries and descriptive statistics about the sample, including data displays to capture the range of attitudes. Qualitative data and analyses have been given priority over the quantitative with the implementation of data collection occurring sequentially (Lopez-Fernandez & Molina-Azorin, 2011). Qualitative analysis generated themes to describe YCATM in-depth in the form of narrative analysis. Geertz (1993) notion of "thick descriptions" has been used as children's attitudes are "not reducible to simplistic interpretation" (Cohen et al., 2018, p. 17). Thick descriptions have been used to describe the complexities of the two contexts and the nature of YCATM describing the complexity of a situation, as classroom events and interactions" (Cohen et al., 2018, p. 17). In doing so, answering the broad research question:

'What is the range and nature of young children's attitudes towards mathematics, in a non-lesson context?'

Data Analysis

As previously mentioned, children's drawings were the incipiency of the other three data collection methods, resulting in three artefacts from the non-lesson context. The data generated were analyzed using multiple methods. Figure 2 summarises the data analyses techniques used to analyze the generated dated.

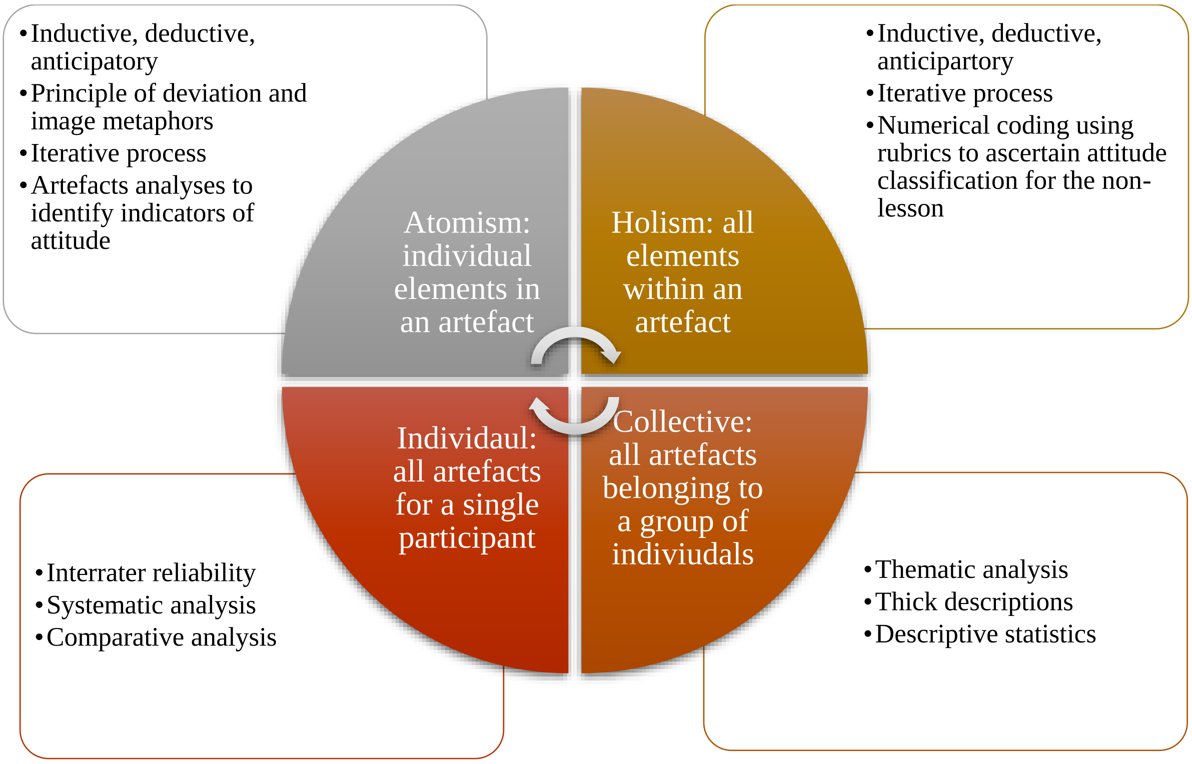


Figure 2. Data Analysis Techniques employed to analyze the Generated Data

A comprehensive rubric was developed to analyze the non-lesson context data. Each sub-dimension included a description of the main idea for each attitude classification are outlined in Table 3. The main ideas shown in Table 3 are not intended to be used a standalone measure of a child's attitudes. Rather, they provide a general description of the attitude classification for each sub-dimension.

Table 3. Main Theme of Attitude Classifications for Each Sub-Dimension

Attitude Classification	**Emotional Tendency**	**Overall Sentiment**	**Topic, Tasks and Processes**	**Value and Appreciation**	**Mathematical Mindset**	**Self-Concept**
Can not be classified	The child is not drawn, or the drawing is incomplete	The child does not depict, describe or mention and	The child has depicted no mathematical topics or connections	The child does not depict, describe, or mention any value or	The child does not depict, describe, or mention any positive norms	The child does not depict, describe, or mention their self-concept

Attitude Classification	Emotional Tendency	Overall Sentiment	Topic, Tasks and Processes	Value and Appreciation	Mathematical Mindset	Self-Concept
		emotions or feelings towards mathematics	between topics	usefulness of mathematics		
Extremely Negative	**Extremely Negative** The child is portraying that they hate mathematics.	**Extremely Negative** The child thoughts, opinions or ideas about mathematics are extremely negative	**Minimal Vision of Mathematics** One or two mathematical topics. No connection between topics	**No value of mathematics** The child does not appreciate or value mathematics at all	**Fixed Mindset** The child sees themselves as unchanging and unchangeable	**Extremely low perceived competence** Expectancy for success, and academic self-concept is extremely low.
Negative	**Negative** The child is portraying that they do not like mathematics.	**Negative** The child shares thoughts, opinions or ideas about mathematics that have a negative sentiment	**Low Vision of Mathematics** Three to four mathematical topics. One connection between mathematical topics.	**Low value of mathematics** The child has a low appreciation and value of mathematics and does not see how the relevance of mathematics	**Low Growth Mindset** Change and growth are very limited as viewed by the child.	**Low perceived competence** Expectancy for success and academic self-concept is low
Neutral	**Neutral** The child is portraying a lack of emotion, or that they are bored or both positive and negative indicators are present	**Neutral** The child's emotional associations, thoughts opinions or ideas about mathematics are mixed or ambiguous or they share sentiments that are both negative and positive	**Developing Vision of Mathematics** Five to six mathematical topics and/or two or more connections between mathematical topics are shown	**Some value of mathematics** The child has a limited appreciated or value of mathematics, only seeing the importance as a school subject	**Mixed Mindset** Limited growth mindset or has indicators from both a Growth/High Growth Mindset and Low/Fixed Mindset.	**Neutral** Expectancy for success is neither low nor high or the child has indicators from a low/ extremely low and high/very high perceived competence

Attitude Classification	Emotional Tendency	Overall Sentiment	Topic, Tasks and Processes	Value and Appreciation	Mathematical Mindset	Self-Concept
Positive	**Positive** The child is portraying that they like mathematics.	**Positive** The child shares thoughts, opinions or ideas about mathematics that have a positive sentiment	**High Vision of Mathematics** Seven to eight mathematical topics, three to four connections between topics are made and two or more tasks identified.	**High value of mathematics** The child has a high value and perceived usefulness of mathematics with at least two of the following indicators	**Growth Mindset** The child sees themselves as capable of growth	**High Perceived Competence** Expectancy for success and academic self-concept is high
Extremely Positive	**Extremely Positive** The child is portraying that they love mathematics	**Extremely Positive** The child shares thoughts, opinions or ideas about mathematics that have an extremely positive sentiment	**Exemplary vision of mathematics** More than nine mathematical topics, multiple connections between topics are made and child discusses multiple tasks.	**Very high value of mathematics** The child has a very high value and perceived usefulness of mathematics with at least four of the following indicators.	**High Growth Mindset** The child understands they can change their most basic characteristics and are capable of significant growth	**Very High Perceived Competence** Expectancy for success and academic success is very high.

An excerpt from the non-lesson context rubric, used to analyze the generated data, is provided in Table 4. For each sub-dimension, a single attitude classification and all indicators are shown. These two examples were randomly selected to demonstrate how the code development process was employed to establish the indicators.

Table 4. Code Development for the VA and SC Sub-Dimension (Non-Lesson Context)

TMA Dimension	Sub-dimension	Attitude Classification and Indicators	Code Development Process and source
VM	VA	**Very high value of mathematics** Main Idea: The child has a very high value and perceived usefulness of mathematics with at least four of the following indicators. Indicators: (a) Mathematics is needed in life.	Main Idea: inductive based on indicators for the attitude classification. Indicators: (a) Deductive adapted from (Aiken, 1974) to remove reference to "designing practically everything."

TMA Dimension	Sub-dimension	Attitude Classification and Indicators	Code Development Process and source
		(b) Mathematics helps develops a person's mind. (c) Mathematics teaches a person to think. (d) Mathematics is very worthwhile and necessary. (e) Maths is useful. (f) I use maths in other subjects at school. (g) I use maths outside of school. (h) I look forward to learning new maths. (i) I do math problems on my own "just for fun."	(b) – (d) Deductive (Aiken, 1974) (e) – (i) Deductive (Adelson & McCoach, 2011)
PC	Self-concept	**Low Self-concept** Main Idea: Expectancy for success and academic self-concept is low. Indicators: (a) Negative/bad thoughts/sentiments about maths ability/competence (b) Nervous about making mistakes. (c) Nervous when teacher askes a maths question (d) Worried about tests and not doing well. (e) "It takes me a long time to complete my work as I don't always get it straight away." (f) "I'm unable to understand maths concepts." (g) "I forget the maths concepts that I learn, and it makes me feel dumb/silly/bad …" (h) I give up. (i) Rates self lowly (3 or 4 out of ten)	Main Idea: inductive based on indicators for the attitude classification. Indicators: (a) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) to include negative and reference to maths ability/competence (item 78) (b) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) to specify "making mistakes" as this was induced from drawings (item 28) (c) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) to specify maths question (item 7) (d) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) to specify not doing well (item 10) (e) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) original item "be slow in school work" (item 26)

TMA Dimension	Sub-dimension	Attitude Classification and Indicators	Code Development Process and source
			(f) Deductive adapted from (Alexopoulos & Foudoulaki, 2002) to include maths concepts (item 53) (g) Deductive and inductive adapted from (Alexopoulos & Foudoulaki, 2002) – original item “forget what I learn” (item 66) (h) Deductive (Alexopoulos & Foudoulaki, 2002) (item 20) (i) Inductive – from children’s interview responses

The rubric developed for the non-lesson context went through several iterations before the commencement of data collection. An example of the iterative process is included to demonstrate how the rubrics were refined. An early iteration of the non-lesson context rubric included ten sub-dimensions for TMA, including sub-dimensions relating to teachers and classroom environment. Two sub-dimensions focusing on teacher activity and teacher involvement were deleted as the focus of this study is on children’s attitudes and not on teacher activity. Children were not explicitly asked to include others, such as teachers, in their drawing, and if a child drew a teacher, then this was considered as part of that child’s vision of other TMA sub-dimensions. Children who did not draw a teacher would have been given a lower score that was not a true reflection of their attitudes towards mathematics. The six sub-dimensions were amended to include indicators for the teacher’s involvement and activity.

Each drawing, written description and transcribed interview was viewed initially as three separate pieces of data and then as a collection of work. Two main coding systems were then employed. First, a systematic analysis using the principle of atomism was used to examine each drawing (Bachman et al., 2016) using the non-lesson context rubric.

Children’s drawings were analyzed to identify indicators for each attitude classification within each Modified MTMA sub-dimension, starting with the child’s face and moving to the whole child to ascertain their Emotional Tendency and Overall Sentiment. Several iterations of analysis of the children’s drawings were completed for the remaining five sub-dimensions. Once the drawing was examined at the atomic level, drawings were viewed holistically (Bachman et al., 2016).

The process of analyzing at the atomic and holistic levels was repeated with the child’s written description and interview responses. Once the data generated from the three individual data collection techniques were analyzed, they were combined to form a more comprehensive picture about YCATM. The drawings were annotated with clarifying and supportive statements that the child made during the interview. A rubric was developed to ensure consistent coding.

Each rubric includes the main idea for each attitude classification, and several indicators are listed for each attitude classification. It is important to note that for any given attitude classification, a child does not have to have all the indicators present to be coded with the associated score. The list of indicators is not exhaustive; rather, the indicators provide guidance to the score for each attitude classification. The systematic analysis provided the scope to report findings on the nature of YCATM. Second, numerical coding which used the principle of holism provided the scope to report findings on the range of YCATM.

Findings

The findings from the study are reported in two sections. The first section reports findings that address the range of YCATM and are presented using the sub-dimensions shown in Figure 1. The second section reports findings that address the nature of YCATM and are presented using attitude classifications shown in Table 5.

The Range of Attitudes

Numerical coding was used to classify the range of YCATM in both the non-lesson and lesson context using the developed rubrics. Each sub-dimension was divided into six categories, and each category was allocated a score from zero to five. The six scores for each sub-dimension were then added to give an overall score out of 30, providing a quantitative measure to ascertain the range of children's attitudes towards mathematics (Quane et al., 2019). Table 5 provides the intervals and classifications of attitudes.

Table 5. 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

Adding the six sub-dimension scores together produces a total score that classifies a child's Attitude towards mathematics. The distribution of scores then provides information about the *range* of YCATM. The inclusion of descriptive statistics (see Table 6) shows the spread of scores for each sub-dimension, dimension, and overall attitude score.

In the non-lesson context, sixty percent of year 2 and 3 children were classified as having a Positive (n=55) or Extremely Positive (n=9) attitude towards mathematics. Twenty nine percent were classified as having a Neutral Attitude (n=31) and eight percent as a Negative Attitude (n=9). A male, year 2 child was classified as having an overall Extremely Negative Attitude towards mathematics. One child (female, year 3) was excluded from further analysis as this child Could not be Classified for four of the six sub-dimensions, resulting in an overall attitude classification of four out of thirty.

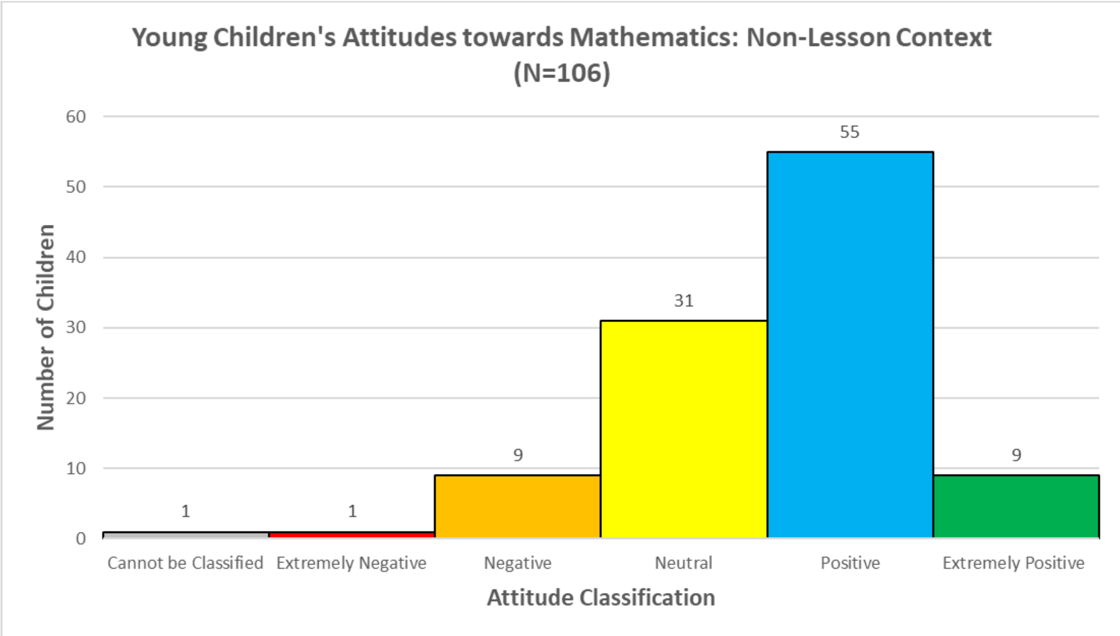


Figure 3. Children's Overall Attitude Classification in A Non-Lesson Context

In a non-lesson context, participants on average were classified as having a Positive Attitude towards mathematics (*M*=20.82). The interval for a Positive Attitude classification is between 16–20. Integers are used to classify YCATM, therefore the mean has been rounded to the nearest whole number, indicating that, on average, children had a Positive Attitude towards mathematics. This result is on the cusp of the Neutral/Positive classification as the upper bound for a Neutral Attitude is 20. The intervals for each scale are arbitrary and this finding is reported to demonstrate the importance of examining Attitude from multiple perspectives and not just quantitatively.

Table 6. Descriptive Statistics of YCATM by Sub-dimension

Dimension	M^a	S^a	*Min*	*Mdn*	*Max*
ET	3.55	0.77	2	4	5
OS	3.59	0.82	0	4	5
TOTAL ED	7.14	1.40	3	7	10
TTP	2.78	1.14	0	3	5
VA	3.64	0.97	0	4	5
TOTAL VM	6.42	1.86	0	7	10
MM	3.54	0.98	0	4	5
SC	3.72	1.03	0	4	5
Total PC	7.25	1.79	0	7	10
TOTAL ATTITUDE	20.82	4.22	4	22	28

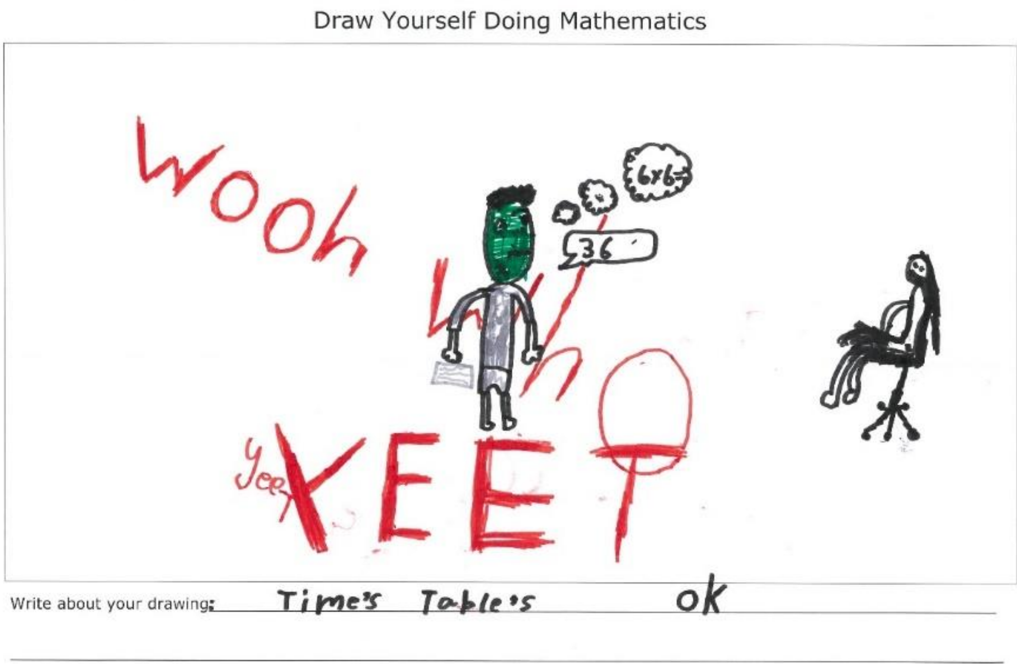
Table 4 provides an indication that there a range of attitudes are evident, and that children's Vision of Mathematics appears to have the greatest impact on their overall Attitude towards mathematics. Examining the nature of YCATM provided further valuable insights into the dimensions of Attitude.

The Nature of Attitudes

The nature of YCATM is complex, varying from individual to individual, providing great insight into the factors that contribute to YCATM. Four cases with different attitude classifications have been selected that exemplify the interwovenness of the six sub-dimensions of the MTMA. For each case, the individual attitudes classifications have been provided beneath the child's drawing.

Negative Attitude towards mathematics

C9 (Year 2, Male) has drawn himself as Frankenstein's Monster and reveals that he feels "disgusting" and has characterized himself this way "because Frankenstein is stupid." He has drawn his teacher sitting on a chair to the right-hand side of himself and has drawn the teacher with a small head resulting in the appearance that the teacher is wearing a mask (see Figure 4).



Dimension	ED		VM		PC		TOTAL
Sub-Dimension	ET	OS	TTP	VA	MM	SC	
Score	2	2	2	3	1	2	**12**

Figure 4. C9's Drawing, Written Response and Attitude Classifications

C9 was asked about the teacher and his intention to depict her the way he has. Rather, the mask was the teacher's mouth which was intended to be drawn "ah a bit like straight…cause she does her work and she needs to do her

work." By asking the C9 about the teacher we learn the child's intention, highlighting a potential issue with the use of Textas and the scale of drawing.
C9 has drawn a wriggly line for his mouth, explaining that he felt confused about the answer to "6 x 6," stating "I'm confusing [sic] if it's thirty-six or thirty-three". This prefaces the words that child has drawn in large red letters. C9 has written "Wooh Who" [sic: Woo Hoo] and "Yeet" and was asked to explain why he had written these two words and used the colour red. C9 responded, "because that's the one for the best writing." The child used both words as an act of celebration in determining the correct answer to the multiplication question. However, the word "yeet" had a double meaning for C9: for him, "yeet" was a "weird word" that is an example of a "meme." C9 modelled using the word "yeet" to celebrate and to express frustration, speaking the word upon completion of the question using a full and guttural voice.

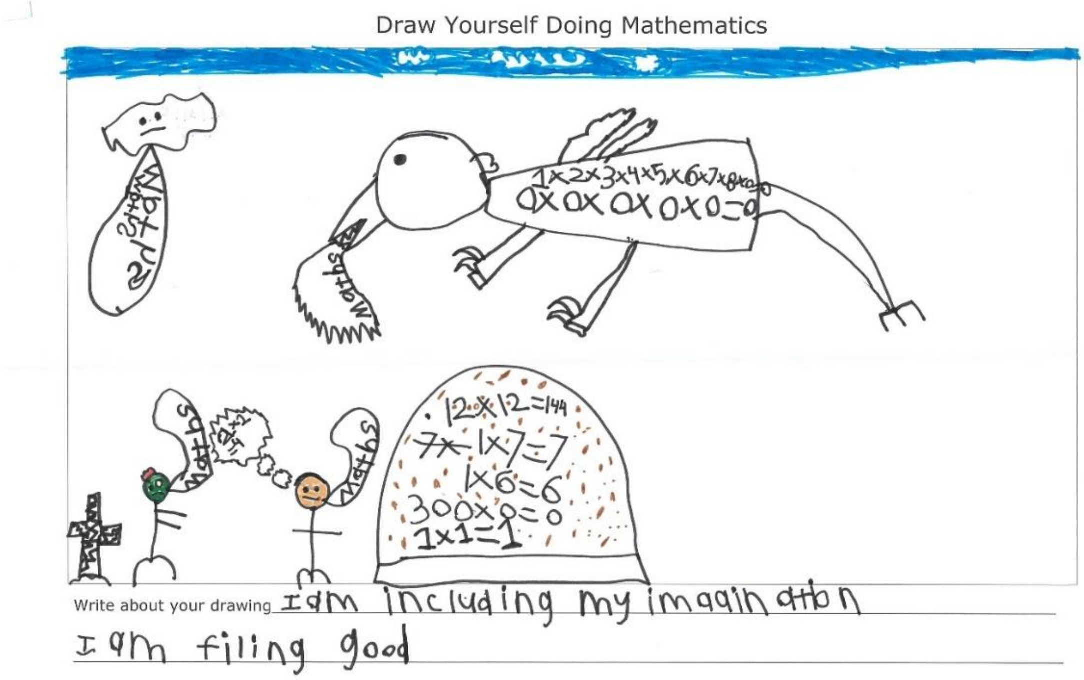
While the drawing celebrates a moment of success in mathematics, C9 mentioned that these celebratory moments were not experienced often. C9's written description indicates that he is doing times tables and feels okay. However, during the interview, C9 reveals that he starts "to hate maths then I like it again then I hate maths." The child explains that his love/hate relationship occurs about "fifty-fifty" and provided examples of when he hated and liked mathematics."

C9 was classified as having a Fixed Mindset (MM) and having a Low PC regarding his mathematical ability. He rated himself a three out of ten with the reason: "because I'm not that good at maths… because I mostly talk to my friends." C9 explains that he talks to his friends "because it took me like five minutes to do one question." The time taken for C9 to complete a single question causes embarrassment and bad feeling when he makes mistakes.

C9 shares his views and relationship with mathematics vividly. The use of an iconic figure such as Frankenstein's Monster immediately conjures up images of monstrous experiences and hideous creatures. As the Mary Shelley character, Frankenstein's Monster experienced alienation and rejection by society and for C9 using the image may carry related meanings: that he is rejecting mathematics and may feel alienated as he believes that he is slow ("it took me like five minutes to do one question") and makes mistakes. C9 has used this imagery in a powerful way to convey his "disgust" and hatred for mathematics and in doing so creating an image metaphor (Larkoff, 1987). C9 appears to want to understand the mathematical concepts that he is learning but is restricted in asking for assistance or understanding that learning and understanding mathematical concepts takes time.

Neutral Attitude towards mathematics

Similar to C9's drawing, A19's (male, year 2) drawing depicts mythical creatures (Figure 5) in the form of a zombie and a dragon. The written description A19 has provided, indicates that he is using his imagination. A19 has drawn a humanized archetype of a zombie that appears to be slowly approaching A19, who is standing in front of a large burger with several multiplication facts. A19 has drawn a dragon with two multiplication facts directly above the burger. To the left, A19 has anthropomorphized a cloud who is "feeling worried and mad cause [sic] it's feeling worried that I might be eaten by the zombie but it's feeling mad that it can't hold pencils or walk on the ground." A19 was asked about the individual elements of his drawing and how they relate to mathematics which is shown in the following excerpts:



Dimension	ED		VM		PC		TOTAL
Sub-Dimension	ET	OS	TTP	VA	MM	SC	
Score	3	3	1	4	4	4	**20**

Figure 5. A19’s Drawing, Written Response and Attitude Classifications

Interviewer: tell me about your picture?

A19: so, the zombie is supposed to be the table and the grave is supposed to be the chair, the dragon is supposed to be the pencil, the hamburger is supposed to be the paper and the cloud is supposed to be the rubber, and the sky and clouds are there are supposed to be the roof and the grassy ground is supposed to be the floor.

From the above excerpt, A19's drawing is an allegory for a classroom with each element representing a common classroom item (zombie representing a table; grave representing a chair etc.). The allegory used by A19 is not immediately obvious, rather it is an elaborate metaphor that needs further dissecting. Further questioning was required to understand A19’s connection to the individual components of his drawing:

Interviewer: Where are you in this picture?

A19: I'm in front of the zombie, below the dragon and behind the hamburger.

Interviewer: Tell me about you? How did you draw yourself?

A19: I drawed [sic] it as a stick person with a round head, eyes and a line mouth and I put a thinking bubble of 2 x 2 = 4 and a speech bubble saying 'maths' and the zombie is also saying 'maths' and the cloud is saying 'maths, maths' and the dragon is just saying maths

Interviewer: let's just go to your face for the moment. Tell me why you drew a line for a mouth?

A19: cause [sic] I don't want to draw a big smiles [sic] cause they'd go over the eyes.

Interviewer: but how are you feeling in this picture?

A19: Good.

Based on the A19's description we learn that he feels good given the context that he describes. However, further investigating we learn that A19 doesn't always feel good when doing mathematics as shown in the excerpt below:

Interviewer: how do you feel about maths?

A19: sometimes hard, sometimes easy, sometimes confusing

Interviewer: sometimes confusing. When you find it hard, how do you feel?

A19: mmmm, I feel like I have to guess it again and retry.

Interviewer: how does that make you feel?

A19: mmmm, makes me feel more confident.

Interviewer: can you give me an example when it's confusing?

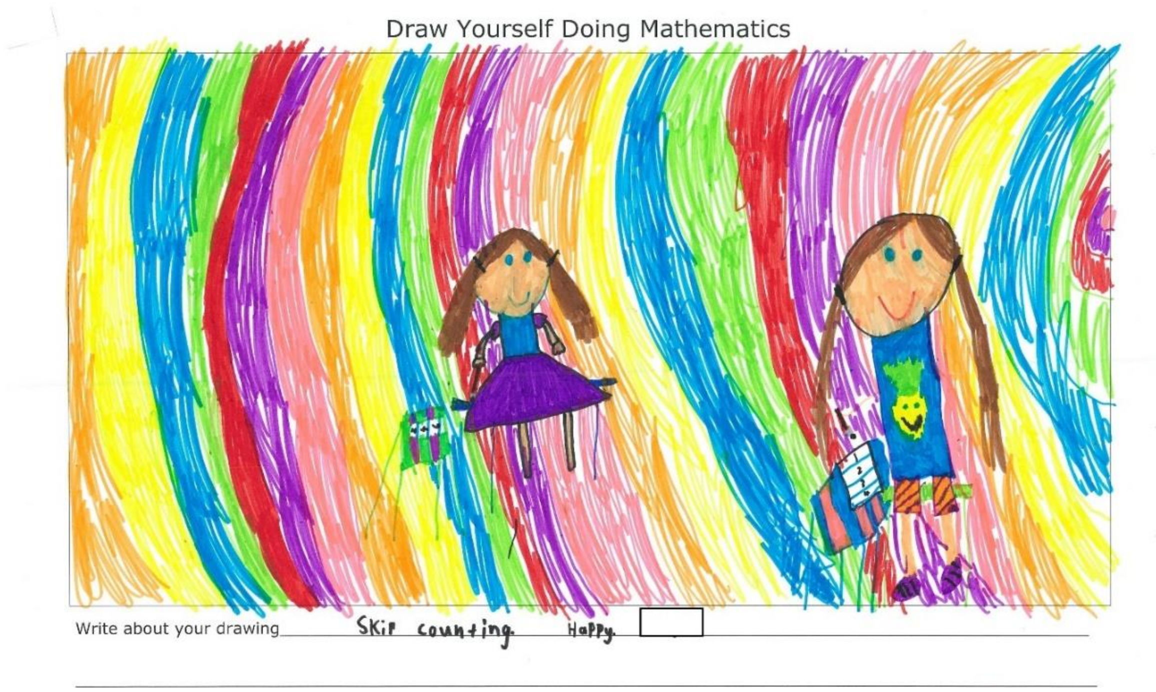
A19: like when there's so many sums then I forget what I'm supposed to do.

From the above excerpt, we can see that A19 is starting to exhibit a range of emotions towards mathematics and was asked if he felt other emotions during mathematics. A19 described feeling bored, which he attributed to how the zombie felt. These mixed emotions resulted in A19 being classified as having a Neutral ET and OS. A19 associated mathematics with multiplication facts, resulting in a Low Vision of Mathematics. Initially, when A19 was asked to rank himself out of ten as a mathematics student, he gave himself a mark of “3008 out of ten” as it meant that he could do “more maths”. Whilst the child’s self-rating is extremely high, his explanation from the above except and other interview responses indicated that he was not always confident in the mathematics that he was completing resulting in confusion. A19’s score for the Topic, Tasks and Processes sub-dimension impacted heavily on his overall attitude classification.

Positive Attitude towards Mathematics

A25 (female, year 2) has drawn herself on the left wearing a skirt and a peer. Her drawing is bright and vibrant with the child indicating that the rainbow that she has drawn is full of patterns, an indicator of the Topic, Tasks and Processes VM sub-dimension. A25 indicates that she “wanted to make her own pattern” describing it as “colourful” and “fun”. These indicators point to a positive attitude towards mathematics. A25 also discusses number topics and, in particular, skip counting. The child has shown a range of mathematical representations in her drawing. By asking A25 we learn about the significance of the rainbow and other elements in her drawing and importantly providing indicators of her Attitude towards mathematics.

Other indicators of A25’s Attitude is found by asking probing questions such as “if mathematics was a food, what food would it be and why?” A25 describes mathematics as “hard” relating mathematics to an apple as apples can be “hard” and “tricky” as they are “hard to eat”. The child relates her description of an apple to mathematics, indicating that she feels “good” when mathematics is hard stating that “I try to figure it out” and seeks help when required. The child’s VM is reflected in her PC when she indicates that she would rate herself highly, stating again mathematics “is sometimes hard” which makes her “happy”.



Dimension	ED		VM		PC		TOTAL
Sub-Dimension	ET	OS	TTP	VA	MM	SC	
Score	4	5	2	3	5	4	**23**

Figure 6. A25's Drawing, Written Response and Attitude Classifications

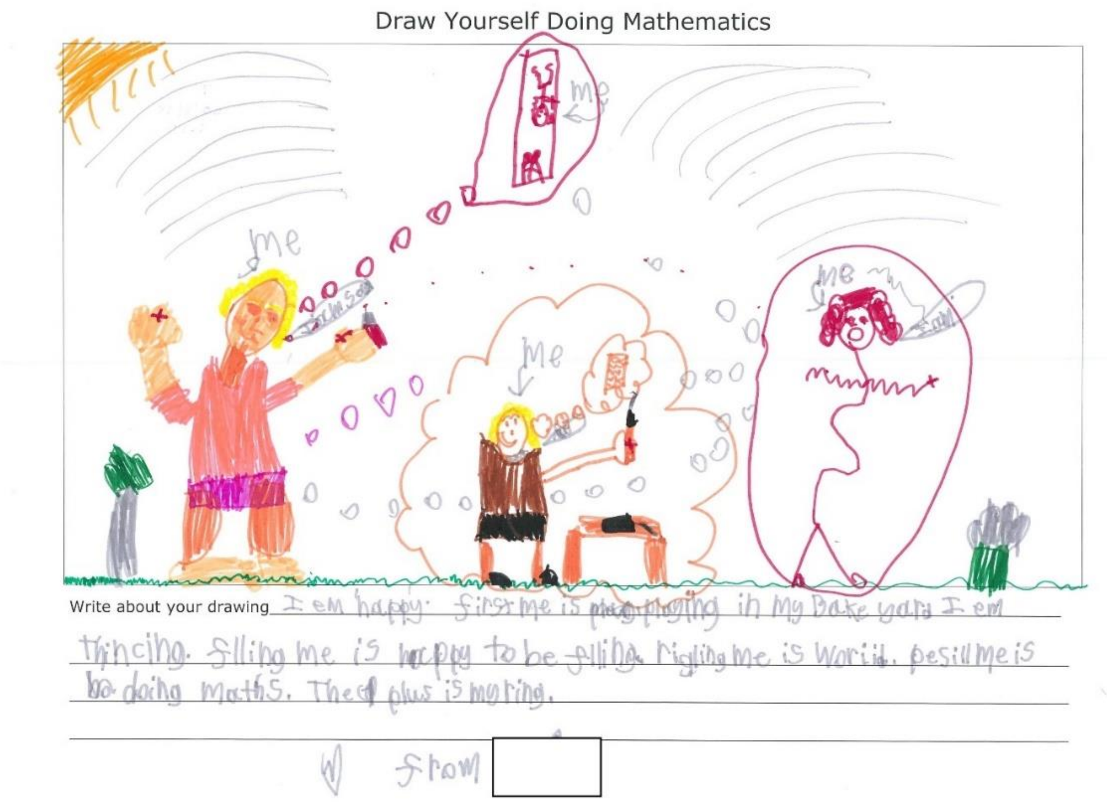
Extremely Positive Attitude towards Mathematics

A7 (Female, year 2) initially drew herself at school, as seen in the middle of her drawing. She then added the three versions of herself, one either side and one above. The child classified the versions of herself as "first me;" "falling me;" "worried me" and "school me." The interview provided A7 the opportunity to describe each version of herself, minimizing misinterpretation. An affordance that would not have been possible without the interview.

On the left of the drawing (figure 7) is what A7 calls "first me" who "is doing maths, and the maths is really tricky and is imagining even more tricky maths." A7 is in her backyard and is happy. She had drawn a ring on her finger depicting a plus sign. This first version is thinking about the other three versions.

The second version is what the child describes as "falling me." A7 has drawn herself upside down, "falling down to get a present" which A7 opens to find "it's got heaps of maths in it." The present contained "tricky maths" which at the time of her drawing, referred to times tables and is mentioned throughout the interview.

The third version depicts the child at school. A7 is smiling and happy, working at her desk, holding a pencil and thinking: "I was thinking about times tables that don't exist but that they [sic] are really hard." On the desk is a piece paper that the child is using to record her work, "it's a black piece of paper because I've done so much maths that it's turned all black cause I did so much maths, because I've finished, and I've filled my page with maths." A7 drawing a piece of paper filled with maths demonstrated that A7 is focusing her attention, willing to complete the required task and document her mathematical learning.



Dimension	ED		VM		PC		TOTAL
Sub-Dimension	ET	OS	TTP	VA	MM	SC	
Score	5	5	3	4	4	5	**26**

Figure 7. A7's Drawing, Written Response and Attitude Classifications

A7 describes the fourth version of herself as "wiggly me." She has drawn herself at school with wriggly lines for her arms and body. Her mouth is opened her eyes are drawn large. A7 appears to be worried and possible misinterpretation could have occurred without explicitly asking the child about her drawing. The following excerpt from the interview provides A7's account of why she is worried:

> **A7:** This is wiggly me. It's worried [sic] because um, because um I'm scared of painting that picture and that I am imagining I'd be worried?
> **Interviewer:** What are you worried about? In this 'wriggly me'?
> **A7:** Um because, um I might get in trouble from my Mum.
> **Interviewer:** For doing what?
> **A7:** Squirting paint on the walls.

Initial examination of A7's drawing could extrapolate that the child is worried about mathematics. It is revealed by asking A7 that she is not worried about mathematics at all, rather she is worried about getting into trouble for painting on the walls. A concern that any child could have if a parent has previously reprimanded them for drawing on the walls. The “picture” A7 is referring to is the “first me” version of herself and was asked whether she worried about doing mathematics, and she responded, "No, I love maths.”

Even when A7 is at home, she is thinking about doing school mathematics and dreaming about receiving presents that contain “tricky maths.” A7 explicitly states that she loves mathematics rating herself as “nine and a half [out of ten] because I don’t always get it right and sometimes when they are easy, I don’t get them right.” A7 elaborated by stating that “I feel really good because I tried my best.” A7’s description of her PC demonstrates that she feels happy even when faced with a setback in her learning, demonstrating perseverance and effort is required to develop mathematical understanding.

Discussion

The results capture the nuance and complex nature of YCATM aged between seven and nine years of age. The four cases, while varying in context and content provide detailed examples of a range of attitude classifications. The multi-dimensional, multi-directional model of MTMA proved to be a valuable strategy in identifying the range of attitudes and more pertinently describing the nature of YCATM. In presenting the four cases we can see the dynamic nature of what children depict, revealing their emotional disposition, their vision of mathematics and their perceived competence. More so, we see how each dimension influences and, in turn, influenced by other dimensions of Attitude. This finding reflects findings reported by other researchers who have used TMA (Di Martino & Zan, 2010; Ding et al., 2015). Modifying the TMA provided a more in-depth exploration of the enactment of YCATM. The modification made to TMA was brought about by using different research techniques to investigate attitudes towards mathematics. We argue that the use of multiple research techniques afforded the rich narratives that were constructed, contributing to our understanding of attitudes towards mathematics and methodologically in terms of using children’s drawings in an innovating way.

Whilst the use of multiple methods is seen as complementary (MacDonald, 2009; Quane, 2021; Quane et al., 2021), we need to be cautious about using a single measure. Children’s drawings, used as a standalone measure, could be problematic in regard to revealing the intent of a child’s drawing and form an incomplete narrative (MacDonald, 2009). Combining drawings with a written description and semi-structured interview provides multiple opportunities for children to share their experiences with mathematics, extending our understanding of the enactment of YCATM. Additionally, using children’s drawings as a basis to identify which students to observe during mathematical learning experiences proved to be invaluable. Brennan (2019) found similar results claiming drawings and written descriptions corroborated observations when investigating second and fifth grade students from Ireland.

As stated previously there is a dearth of research examining YCATM, in particular, from an Australian perspective in the early primary years. Internationally, researchers have investigated specific mathematical strands or a single dimension of Attitude, such as emotional disposition or explored pedagogical approaches that influence attitudes towards mathematics. Given the limited research, it is difficult to make comparisons with the same demographics of children. However, we do see some similar findings in other research which will now be discussed.

One example of similar results identifies the interrelatedness of the six sub-dimensions of MTMA. Towers Towers et al. (2018) found that Canadian primary children also use the dichotomy of “easy” and “hard” (p. 158) associating an emotional response to their attribution. In terms of our study, we see that both A9 and A19 uses theses terms to describe particular topics, tasks and processes (TTP), their mathematical mindset (MM) and their value and appreciation (VA). Additionally, children attached emotions to their view of mathematics when doing a particular task, which provided insights into their emotional tendency (ET) and long term, contributing to their emotional sentiment (ES). Reducing mathematics to the easy-hard dichotomy may be an oversimplification, but it is important to recognize in terms of YCATM. Towers et al. (2018) concur stating that the distinction made by children is “highly significant” and found that four- and five-year-old children make this distinction which “position themselves and others” in relation to the dichotomy.

This study's findings suggest that YCATM enactments vary significantly between children. The rich and thick descriptions led to identifying and explaining actors, acts, actions and artefacts (Spradley, 2016), that influence YCATM. However, not all cases were straightforward to analyze. The case of A19 was purposefully included to demonstrate how, even the most complex drawings can be analyzed. The analytical framework as shown in Figure 2 provided the necessary framework to analyze a complex drawing.

In classifying YCATM there are some inherent limitations. First, the attitude classification was true at the time of data collection. Rokeach (1968) described the construct of Attitude as “relatively enduring”. In contrast, Triandis (1971) claims that “attitude may change at different rates and in different degrees” (p 67). The Trends In Mathematics and Science Study (TIMSS) results would be a possible data set that supports Triandis’ claim with Positive Attitudes towards mathematics declining as a child progresses through school. TIMMS reports data on student achievement and factors related to student learning, including attitudes towards mathematics (TIMSS, 2016). Trends and a broad understanding of children’s attitudes towards mathematics are developed by exploring data sets such as TIMSS. For example, in comparing the percentage of Year 4 students who do not like learning mathematics, Australia (27%), Canada (24%), Turkey (4%) and the international average of 19% to Year 8 students who do not like learning mathematics Australia (50%), Canada (39%), Turkey (30%) and the international average of 30%, a decline is evident (TIMSS, 2016). A conclusion that is plausible from the TIMSS (2016) results is that as students age the more likely they are to dislike mathematics. Other studies using scaled instruments report similar findings (See: EARU, 2013, 2018), illustrating that older students express more of a Negative Attitude than their younger counterparts.

Conclusion

This paper reported result from a study conducted with 106 children, ascertaining their Attitude for a non-lesson context. The results were analyzed and reported using the Modified Three-dimensional Model of Attitude (MTMA). Sixty percent of children were classified as having a Positive Attitude towards mathematics. While this statistic contributes to the understanding of how attitudes develop over time, it is the four cases of children’s attitudes that document in depth how their attitudes are enacted that demonstrating the nuance and often complex relationship with mathematics.

The findings reported in this paper have been delimited to South Australian children. Further national and international research is warranted to determine whether the results reported here can be generalized to a wider population. Conducting a longitudinal study with the children in their subsequent years of schooling to document how children's attitudes change as they progress through school and further education would be of great value to the mathematics education community. In doing so, factors influencing their attitudes could be identified and described. Further, individual attitudinal change could be examined. Additionally, the results reported in this paper draw on findings from the non-lesson context providing value insights into young children's attitudes. Using evidence from lesson observations to corroborate and map evidence from a non-lesson context would provide a richer and more holistic narrative about young children's attitudes towards mathematics.

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