DEVELOPING A MODEL OF MATHEMATICAL WELLBEING THROUGH A THEMATIC ANALYSIS OF THE LITERATURE

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Globally, many students experience low mathematical wellbeing, defined here as the fulfilment of one's core values, accompanied by positive feelings and functioning in the mathematics classroom. To increase positive feelings about and engagement in mathematics, there is a need to better understand students' values and align practices to supporting these values. We report on a scoping review of 40 mathematics education publications. Student values in mathematics education could be categorised into seven wellbeing dimensions, namely accomplishment, cognitions, engagement, meaning, perseverance, positive emotions, and relationships. The resulting seven-dimensional mathematical wellbeing model points to target areas to build student mathematical wellbeing.

INTRODUCTION

Mathematics promotes human flourishing through greater educational and career opportunities, and more informed decisions regarding health, wellbeing, and socioenvironmental issues (Su, 2020). Unfortunately, Australian students' achievement relative to other countries is declining, with a lower proportion of students selecting advanced mathematics courses in upper secondary school (Kirkham, Chapman, & Wildy, 2020; Thomson et al., 2019). These declines have occurred despite the introduction of various policies, curricula, teacher training, and classroom practices over the past several decades to support mathematics performance (Su, 2020). But less attention has been paid to students' subjective experiences in the classroom. For many students, mathematics education is far from a positive experience. Studies indicate that students value social learning, caring relationships, and engaging and meaningful pedagogies (e.g., Hill, Kern, Seah, & van Driel, 2021), but these values are not being fulfilled within mathematics education for many students, resulting in disengagement, anxiety, and boredom being commonly reported by students (Attard, 2013). That is, many students are experiencing low wellbeing in mathematics.

Wellbeing in mathematics education – or 'mathematical wellbeing' (MWB) – is defined here as the fulfilment of core values (Tiberius, 2018) within the learning process, accompanied by positive feelings (e.g., enjoyment) and functioning (e.g., engagement, accomplishment) in mathematics. That is, MWB is not only feeling and functioning well (Huppert & So, 2013), but is a positive state of functioning that results from students' experiences in the classroom aligning with their personal values. For example, a mathematics student who values enjoyment, personalised learning support,

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and solving challenging mathematical problems will likely feel good and engage more with the subject when they enjoy their learning, experience one-to-one teacher support and are given challenging tasks. In contrast, that student might feel unwell and disengage from learning when the learning is perceived as boring and they lack personal teacher support.

For many students, mathematics is a challenging school subject. Students with high MWB are more likely to see the challenge as doable and engaging, whereas students with low MWB are more likely to be overwhelmed by the challenge, further contributing to low MWB. That is, the challenge of the subject is less of an issue than incorporating pedagogies that help students value their learning and thrive through that challenge. We suggest that to improve students' experiences at school, we must attend to their MWB, beginning with understanding and attending to what students value in mathematics education.

To support understanding of these values, we undertook a scoping review focusing on literature documenting student values in mathematics education, exploring conditions associated with positive learning experiences and aligning these with wellbeing dimension proposed in the literature. We defined values in mathematics education as the aspects students consider to be important in the process of teaching and learning mathematics (Hill et al., 2021). Across the 40 publications included in our review (see Hill, 2022), we discovered students' mathematics values aligned with seven wellbeing dimensions. These dimensions were also observed to transcend different student ethnicities and grade levels.

BACKGROUND AND THEORETICAL FRAMEWORK

The concept of wellbeing has many uses and conceptualisations across different disciplines (Chia et al., 2020). Here we focus on students' subjective experiences of feeling and functioning across different dimensions (e.g., cognitive, emotional, and social). Various models of subjective wellbeing have been proposed. For example, Seligman (2011) proposed five wellbeing dimensions: positive emotions, engagement, relationships, meaning, and accomplishment (PERMA). Kern and colleagues (2016) proposed the EPOCH model of adolescent wellbeing, which includes engagement, perseverance, optimism, connectedness, and happiness dimensions.

The value fulfilment theory (VFT) of wellbeing (Tiberius, 2018) asserts that individuals' experiences of wellbeing depend on their values, which can differ across personal, cultural, and contextual conditions (Alexandrova, 2017). For instance, what a student values in mathematics likely differs to what they value in physical education or arts, and thus wellbeing looks different across these subjects. Values are hierarchal. At the highest level, 'ultimate values' are core values that are valued for their own sake. At the next level, 'instrumental values' are the things that are valued to achieve more ultimate values (Tiberius, 2018).

To our knowledge, only two publications have explicitly investigated wellbeing specific to mathematics education. Clarkson and colleagues (2010) proposed a three-dimension MWB model (i.e., cognitive, affective, and emotions), arguing that high MWB was achieved through development in all three dimensions. Part (2012) explored adult learners' MWB in terms of capabilities (valued doing or beings) and functioning (valued outcomes). According to Part, high MWB encompasses students feeling both capable and believing they hold the skills to function well. While these two models are a helpful starting point, both models ignore the important social aspects of mathematics learning and lack corresponding measures. Both were derived from mostly Western ethnic backgrounds. They are also theoretically based rather than incorporating students' perspectives. Yet considering MWB is subjective, students' perspectives are important and necessary. Attending to the criticisms of current MWB models helped inform our search strategy.

METHODS

A scoping review of the mathematics values literature was undertaken guided by Arksey and O'Malley's (2005) scoping review framework. Our guiding research questions were: (RQ1) What types of values are espoused by primary and secondary students in mathematics education that positively impact on their mathematics leaning experiences? (RQ2) To what extent do students' values in mathematics education align with wellbeing dimensions proposed in philosophy, positive psychology, and mathematics education research? And (RQ3), what might be an updated model of MWB that addresses some of the limitations of existing models?

Five databases were searched: Academic Search Complete, Education Research Complete, Education Resources Information Centre (ERIC), ProQuest, and PsycINFO. Our inclusion criteria were that the article was published between 2011 and 2021 (corresponding to the period in which the majority of values research in mathematics education was published); that it focused specifically on mathematics education; that primary or secondary student cohorts were involved; and that students specifically reported their values.

In total, 2,252 publications were exported into Covidence, a review management software. Titles and abstracts were screened as per the inclusion criteria leaving 135 publications. Full texts were then read leaving 40 values publications to be analysed. These 40 publications were then imported into NVivo12 and thematically analysed using a combined inductive/deductive strategy (Braun & Clarke, 2006). We began with a bottom up (inductive) approach to generate data-driven themes (RQ1) with subsequent theoretically driven top down (deductive) analysis to categorise these themes according to the wellbeing literature (RQ2). For RQ1, initial codes were inductively generated. For example, qualitative methodologies were coded from student quotes. Quantitative (survey) methodologies were coded from students' highest ranked values. For RQ2, using a deductive strategy, we aligned the emergent value themes (from RQ1) with seven welbeing dimensions from the literature

categorising the values (identified for RQ1) into one of the seven dimensions, rather than including values across multiple dimensions. Finally, we present an updated model based on the

Deductive WB Themes (RQ2)	Description	Dimension Source	Example Inductive Value Themes (RQ1)
Accomplishment	Valuing achievement, reaching goals, confidence or mastery completing mathematical tasks and tests	PERMA	Accuracy, high marks, goals, confidence
Cognitions	Valuing knowledge, skills, and/or understanding required to do mathematics at school	MWB	Efficiency, recall, prior knowledge, understanding
Engagement	Valuing concentration, absorption, deep intertest, or focus when learning/doing mathematics	PERMA, EPOCH	Attention, interesting work, novel learning, autonomy
Meaning	Valuing direction in mathematics; feeling mathematics is valuable, useful, worthwhile or has a purpose	PERMA	Maths agency, real world links, utility, task value
Perseverance	Valuing drive, grit, or working hard towards completing a mathematical task or goal	EPOCH	Challenging maths, perseverance, practice & hard work
Positive Emotions	Valuing positive emotions when learning/doing mathematics e.g., enjoyment, happiness, or pride	PERMA, EPOCH, MWB	Minimal anxiety, fun, safe climate, pride
Relationships	Valuing supportive relationships; feeling valued, respected and cared for; connected with others; or supporting peers in mathematics	PERMA, EPOCH	Belonging, group work, family support, teacher explanations, teacher warmth & care, peer support

Table 1: Deductive themes, descriptors and accompanying indictive value themes. PERMA: Seligman, 2011; EPOCH: Kern et al., 2016; MWB: Clarkson et al., 2010.

dimensions that aligned between the values and wellbeing literature (RQ3), identifying the percentage that each dimension was mentioned, overall and separated across demographic characteristics (age and jurisdiction).

RESULTS

We found 90 unique emergent value themes which could be deductively categorised according to seven wellbeing dimensions. Table 1 presents the final MWB model, with

the deductively identified themes (column 1), descriptions identified from the literature (column 2), and sources for the deductive model (column 3), along with example value themes identified within the 40 publications included in the scoping review (column 4; see Hill (2022) for full set of coded themes). Across all publications, the most frequent value themes (RQ1) were mathematical *understandings* (12% of total value theme count); *practice, hard work and effort* (12%); *meaningful and relevant learning* (12%); *sharing ideas and peer explanations* (10%); and *teacher explanations* (9%).

Demographic characteristics	Acc	Cog	Eng	Mean	Pers	PosE	Rel	Value Theme #
Overall (*n* = 40 publications)	13%	18%	11%	15%	14%	10%	19%	189
Primary students (7)	11%	17%	11%	17%	17%	8%	19%	36
Secondary students (21)	12%	16%	14%	14%	12%	11%	19%	97
Primary & Secondary (12)	16%	21%	5%	14%	16%	7%	20%	56
Europe (8)	8%	16%	13%	18%	16%	13%	16%	38
Australia/NZ (13)	15%	17%	13%	15%	10%	8%	22%	60
Asia (8)	15%	24%	3%	12%	18%	6%	21%	33
Africa (5)	14%	23%	5%	18%	23%	0%	18%	22
North America (3)	11%	11%	17%	17%	11%	17%	17%	18
South America (2)	17%	17%	17%	8%	8%	17%	17%	12
Mixed countries (1)	17%	17%	17%	0%	17%	17%	17%	6

Table 2: Student demographics, % of value theme mentions by each row/demographic, and total theme count across each row. *Note*. Acc = Accomplishment, Cog = Cognition, Eng = Engagement, Mean = Meaning, Pers = Perseverance, PosE = Positive emotions, Rel = Relationships

Table 2 summarises the percentage of themes identified in the 40 studies across the seven themes overall and by age and jurisdiction. We found relationships was reported most frequently (19% of total count), followed by cognitions (18%) and meaning (15%). Positive emotions were mentioned least frequently (10%). Some differences by age and jurisdiction did occur. For instance, meaning and perseverance were mentioned more by younger than older students. Across ethnicities, notable differences included Europeans valuing accomplishments less often than other ethnicities, Asian and African students reported greater cognitive values than other ethnicities, Africans valued perseverance most, South Americans did not value meaning to a great extent, and positive emotions were rarely mentioned by African students.

DISCUSSION

Here we undertook a scoping review of the mathematics values literature, thematically coding for emergent value themes. Based on VFT, if student wellbeing is about the fulfilment of values, we interpret these mathematics values as conditions or experiences that support student wellbeing in mathematics education. We discovered 90 unique mathematics values themes which aligned with seven wellbeing dimensions proposed in the literature (Clarkson et al., 2010; Kern et al. 2016; Seligman, 2011).

Values relating to relationships in mathematics were mentioned most frequently, which included references to teachers, peers, and families, as well as general belonginess and support. This aligns with research showing students mostly refer to teacher and peer relationships when describing factors supporting their wellbeing in mathematics (Hill et al., 2021). Also, relationships and feelings of connectedness are central to students' conceptions of their own wellbeing (Powell et al., 2018). Cognitions were mentioned second most frequently; this included values relating to mathematical skills and understandings. Students associated cognitions with both positive and negative emotions, suggesting some overlap across the dimensions. For instance, misunderstandings often contributed to anxieties and disliking of mathematics (e.g., Larkin & Jorgensen, 2016). Successful problem solving, and accuracy contributed to pride and enjoyment (e.g., Martínez-Sierra & González, 2014). The progressive yet linear nature of most mathematics teaching and learning can contribute to fear or anxieties about being left behind in a fast-paced curriculum (Gesist, 2010). The cognitive dimension is absent from generalised wellbeing models and was sourced from Clarkson et al. (2010) MWB model. This suggests a generalised approach to student wellbeing might overlook crucial subject specific variations, speaking to the need for greater subject specificity for wellbeing models.

Because wellbeing is value dependent (Tiberius, 2018), how wellbeing is experienced likely differs across student demographics. This was somewhat confirmed in our data. These differences likely reflect students' cultural values. For example, the valuing of perseverance by African students may reflect the high social inequities in Africa and working hard may help transcend these adversities. Yet all seven dimensions, with one exception (i.e., Africans' valuing of positive emotions), were cited by students across cultures and grades. What this implies is that these seven dimensions are still likely important for culturally diverse student cohorts.

A limitation of our review is that we categorised values into one of the seven dimensions. Yet, values often reflect multiple wellbeing dimensions. For instance, valuing hand-on, and practical mathematics learning might align with cognitions (e.g., practical tasks facilitate better understanding), engagement (e.g., they are interesting) or positive emotions (e.g., they are enjoyable). To determine the best category, we would pose the question, *what is the true purpose this value serves for this student?* This was often not possible for survey responses; however, for literal student quotes it generally involved exploring the wider context of the students' experiences. Evidence

suggests wellbeing dimensions are interconnected and complementary (Kern, 2021). For example, feeling accomplished or having meaningful experiences are also generally enjoyable. Similarly, a single value might serve multiple purposes, the same value differently enhancing wellbeing across different life domains. Future reviews might consider what emerges when values are allocated across multiple categories.

CONCLUSION AND IMPLICATIONS

Guided by VFT, our review revealed seven dimensions associated with MWB. This model provides a practical solution to explore and potentially build student MWB. Teachers often struggle describing and implementing wellbeing strategies in individual subjects (Waters, 2021). This MWB model might provide teachers with tangible and measurable dimensions which they can apply in their mathematics teaching. For example, they might consider how to foster positive emotions during mathematics or consider ways to enhance teacher-student relationships. Future studies will look to quantify MWB through surveys guided by this model.

For many students, mathematics learning is far from a positive experience, and often, it is the negative aspects of mathematics that students (and teachers) focus on. This study offers a more positive approach to mathematics learning by focusing on what experiences might enable students to thrive in the study of the subject, rather than the source of their failings.

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