COMPARING STUDENT VALUES AND WELLBEING ACROSS MATHEMATICS AND SCIENCE EDUCATION

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Recognising and supporting student wellbeing in schools has become a global priority. Wellbeing is value dependent and differs across contexts, including school subjects. Even as a growing number of studies, curricula, and programs focus on student wellbeing, applications to specific school subjects are scant. Here we compare 292 grade eight students' conceptualisations of wellbeing in their mathematics with their science classrooms. Findings point to similar values supporting wellbeing in mathematics and science, yet with differences in the hierarchy of these values. This study strengthens understanding of optimal feeling and functioning in specific subjects and points to areas to target to improve students' feelings and functioning.

INTRODUCTION

Mathematics and science education often have poor participation in advanced subjects at schools and universities, under-representation of females and minority groups, and pervasive academic disengagement (English, 2016), suggesting that there is poor student wellbeing in these subjects. Maths and science subjects typically focus on academic performance and functioning, with little consideration of student wellbeing, defined here as the fulfilment of core values within the learning process, accompanied by positive feelings (e.g., enjoyment) and functioning (e.g., engagement) specific to the subject (Hill et al., 2022). Higher student wellbeing is associated with better academic achievement, greater participation, and improved retention in STEM subjects (Watt et al., 2019). We suggest that mathematics and science education require a paradigm shift, moving from the over-emphasis on academic performance to include a greater focus on student wellbeing.

Whilst the cultivation of student wellbeing in schools has become a global priority (e.g., United Nations, n.d.; Kern & Wehmeyer, 2021), how wellbeing looks and operates in individual subjects remains poorly understood. A whole school wellbeing approach can be problematic because just like a grade point average masks subject differences in academic performance, global measures of wellbeing at school hides subjects in which students are flourishing or languishing. When the language of and principles of wellbeing are targeted and contextualised, students can better articulate and adapt wellbeing into their learning context (Oades et al., 2021).

According to value fulfillment theory of wellbeing (Tiberius, 2018), students' values point to the conditions required for them to thrive within specific contexts. Just like grades can vary in one subject versus another, what a student values in one subject (e.g., mathematics) can differ from another (e.g., science) – thus wellbeing might also vary across subjects. Whilst several recent studies have explored the values supporting

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students' wellbeing in mathematics (e.g., Hill et al., 2021; 2022), how these values differ across subjects is yet to be determined and thus is the focus of this study.

BACKGROUND AND THEORETICAL FRAMEWORK

We define student wellbeing according to value fulfilment theory, where individuals' experiences of wellbeing depend on their values (Tiberius, 2018), which can differ across personal, cultural, and/or contextual conditions (Alexandrova, 2017). At the highest level are 'ultimate' values (UV), the things valued for their own sake (e.g., close personal relationships), which are also the most impactful indicators of wellbeing (Tiberius, 2018). These ultimate values can be fulfilled in many ways through various 'instrumental' values (IV), like valuing friendships, group work, or respect to promote close relationships (an UV). Instrumental values differentiate individuals, whilst UVs tend to be consistent across individuals (Tiberius, 2018).

When values are fulfilled, it coincides with subjective experiences of feeling good (i.e., hedonia) and functioning well (i.e., eudemonia) (Huppert and So, 2013). Applied to mathematics education, a student who values working collaboratively would likely feel happy and engage more during collaborative opportunities, whereas the student would disengage with singular activities. Applied to science education, a student who values active activities would feel happy and engage during interactive sessions, whereas the student would disengage with lecture-based pedagogies. Most modern wellbeing models include both hedonic and eudemonic dimensions (e.g., Huppert & So, 2013; Kern et al., 2016; Seligman, 2011). Here we specifically focus on Seligman's PERMA model (Positive emotions, Engagement, Relationships, Meaning, and Accomplishment; Seligman 2011); Kern's EPOCH model (Engagement, Perseverance, Optimism, Connectedness, Happiness; Kern et al., 2016); Ryan and Deci's self-determination theory (2017); and Mathematical Wellbeing (MWB; Clarkson et al., 2010; Hill et al., 2022).

Several recent studies have explored student wellbeing in mathematics. A scoping review revealed seven ultimate values (UVs) supporting student MWB (accomplishments, cognitions, engagement, meaning, perseverance, positive emotions, and relationships; Hill et al., 2022). Australian and Chinese students mentioned these same seven UVs when describing factors and learning moments contributing to their MWB (Hill et al., 2021; Hill & Seah, 2022). A survey with New Zealand students discovered students' mathematical wellbeing declined over the primary to secondary school years (Hill, Bowmar et al., 2022). In mathematics, these seven UVs appeared across diverse student groups and countries. However, it remains unclear if students' values and wellbeing in mathematics appears in other subjects. We begin with science education because of its interrelatedness with mathematics. Along with the seven UVs identified in mathematics education, we add autonomy, which has also been identified in the literature as a core wellbeing construct. Scoping reviews (e.g., Hill, 2023) revealed science students valued autonomous learning. Additionally, self-determination theory posits autonomy as one of three basic psychological needs supporting wellbeing (Ryan & Deci, 2017). Thus it made sense to include autonomy as a dimension. We ask: *How do the same students' conceptualisations of their wellbeing in mathematics differ to science across these eight dimensions?*

METHODS

Participants included 292 grade eight students (51% females), aged 13–14 years attending 1 of 8 urban and regional schools in and around Melbourne, Australia. Ethnicities included 214 Australian, 21 European, 33 Asian, 19 Indian/Pakistani, 2 Indigenous Australian, 2 South American, and 1 Middle Eastern student.

Students completed two surveys: one on their mathematics wellbeing during a mathematics lesson, the other on their science wellbeing during a science lesson. The wording of each survey was identical except for referencing either mathematics or science. Here we focus on the open-ended questions included in the surveys: 1) What makes you feel good and function well in [maths/science], and why? 2) What is the most important thing for you when learning [maths/science], and why?

Earlier studies (e.g., Hill et al., 2021) found the first survey questions, aligned with Huppert and So's (2013) definition of wellbeing, prompted students to reflect on more holistic components of their learning and wellbeing (e.g., friendships, enjoyment, family). The second questions, which were derived from value fulfillment theory (Tiberius, 2018), explored values (i.e., anything that is important) and provoked more academically related reflections (e.g., achievement, academic skills). By combining and coding these two survey questions together, we hoped to capture a holistic conceptualisation of students' wellbeing across both subjects.

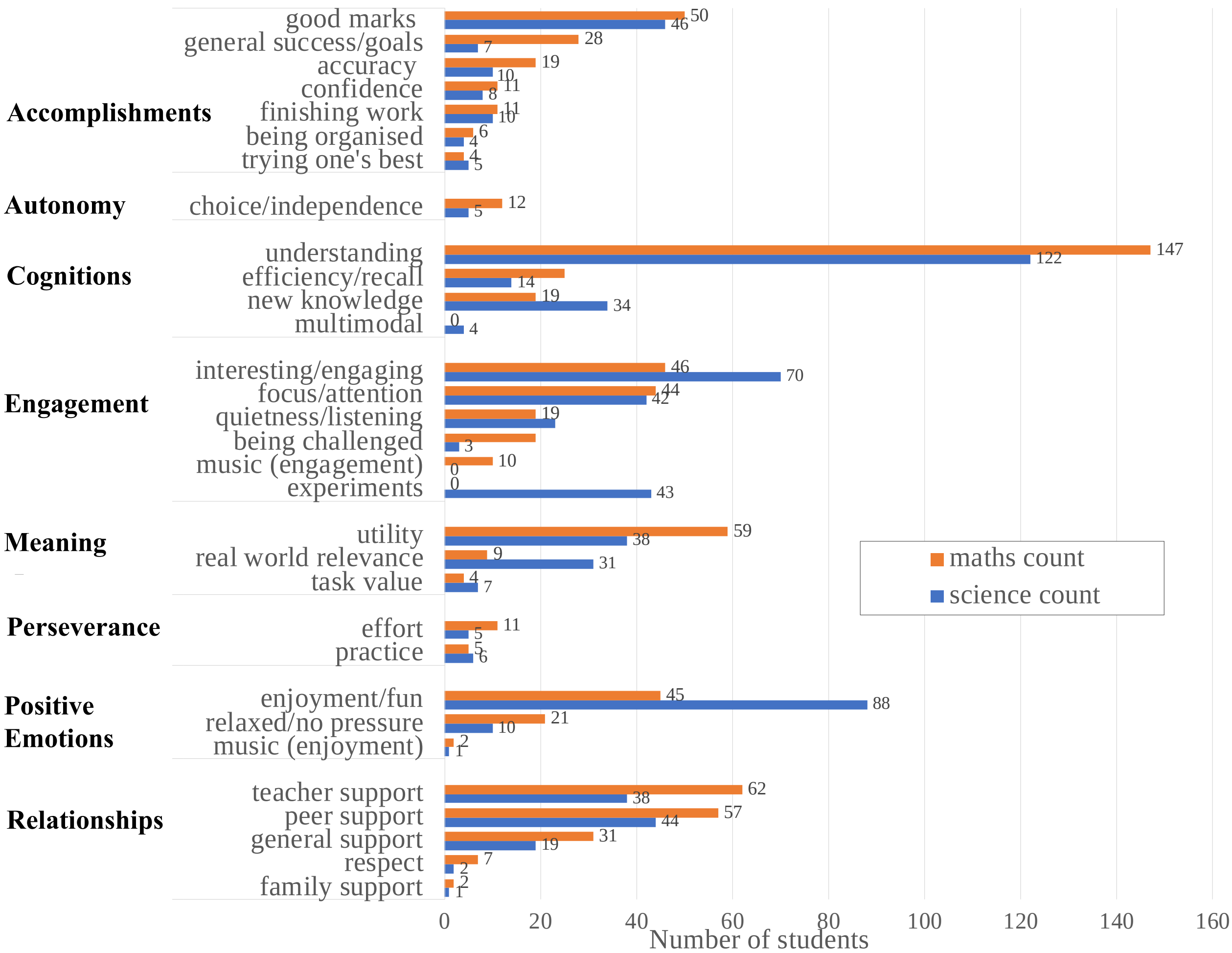
Student responses were analysed using NVivo12 using reflexive thematic analysis (Braun & Clarke, 2019). Initial inductive codes were generated using a data driven approach, for instance *"it will help me in the future"* was coded as *utility*. Next, these inductive codes were categorised deductively into the eight wellbeing themes identified in the literature. Figure 1 summarise the process of categorising inductive codes into the deductive wellbeing components.

RESULTS

Figure 1 summarises the overall frequency of inductive codes in mathematics (orange bars) and science (blue bars). Importantly, the majority of codes appeared in students' conceptions of their wellbeing in both mathematics and science, except for multi-modal representations and experiments – mentioned for science only. At the group level, the same eight UVs emerged across both disciplines, summarised in Figure 1. At the individual student level, there were statistically significant associations between students mentioning each UV in both mathematics and science education, except for engagement, because students associated engagement more with their wellbeing in science than in mathematics. The closest associations across subjects was for relationships, perseverance, and meaning.

The students valued peer support more than teacher support when studying science, but this relative valuing was reversed when these same students were engaged with mathematics. Students valued being interested in their science learning more than in their mathematics learning– often because students equated engaging experiments with their wellbeing. Likewise, enjoyment and fun were noted more often when learning science than mathematics. When learning mathematics, students equated being challenged, understanding their learning, and feeling successful/achieving goals with their wellbeing more than in science. Whilst valuing utility and links to employment were noted more in mathematics than science, students valued real world relevance more for their science than their mathematics learning.

Figure 1. Inductive value frequencies. Bars and data labels represent the number of students mentioning each inductive value for mathematics (orange bars) and science (blue bars).



The hierarchy of UVs differed slightly across subjects (see Table 1 for student frequency counts), with students in science valuing cognitions most frequently, then engagement, relationships, accomplishment, meaning, perseverance, positive emotions, then autonomy. The same students valued cognitions most when learning mathematics, followed by relationships, engagement, accomplishments, meaning, perseverance, positive emotions, then autonomy.

Table 1. Frequency of students mentioning themes in science, maths, and both subjects. Both M + S = Number of students mentioning theme for both maths and science; χ^2 = difference of mentions in science versus maths.

Ultimate value	Science #	Maths #	Both M + S	χ^2	*p*	ϕ
Accomplishment	75	108	46	25.7	<.001	.30
Autonomy	5	12	2	16.63	<.001	.24
Cognitions	144	182	107	17.36	<.001	.24
Engagement	139	109	58	2.19	.14	.02
Meaning	71	67	34	33.01	<.001	.34
Perseverance	11	16	5	35.27	<.001	.35
Positive emotions	11	16	5	4.90	.03	.13
Relationships	89	140	67	38.32	<.001	.36

DISCUSSION

Earlier studies (e.g., Hill, Kern et al., 2022) identified seven UVs supporting MWB and here we examined if these seven UVs, plus autonomy, appeared across both mathematics and science. Students tended to mention the same eight UVs across both subjects. However, engagement was more associated with students' science than mathematics wellbeing. Taken together students' values and conceptions of their wellbeing across mathematics and science appear to be similar.

However, our results also point to subtle subject-related differences in IV. For example, students valued interesting and engaging pedagogies (especially experiments), enjoyment, and real-world relevance more for science than in mathematics. This is not surprising, considering that science is often more hand-on, humanised, and embedded in real-world contexts than mathematics (Bishop et al., 2006). Also, here we focus on Year 8 students – a period when experiments in science are still novel (Abrahams, 2011), potentially contributing to the higher valuing of interesting pedagogies in science than in mathematics. Students (and teachers) often perceive experiments as the fundamental appeal of science (Abrahams, 2011), exemplified by a student in our study noting *"science is the only subject where I get to blow stuff up"*.

Whilst science experiments may offer immediate engagement, students often remember only what they did, rather than remembering the intended learning outcomes (Abrahams, 2011). Students in our study valued mathematics more for utilitarian purposes, and for success in life compared to science, perhaps because mathematics was perceived as essential for everyday life and employment more than something to enjoy and be interested in. Also, in other studies, students often linked science with entertainment and fun, such as museums, exhibitions, and science documentaries, which differs from mathematics (Bishop et al., 2006) – potentially contributing to higher interest values in science than mathematics.

Conversely, students valued cognitive aspects more for their mathematics than their science learning, thus mathematical understanding was especially important for students' MWB. The relationship aspects, especially teacher support, were also more associated with wellbeing in mathematics than in science. Conversely, in science, the students valued support from peers, perhaps because science pedagogies are often more collaborative in nature. Students often see mathematics as progressive, abstract, and linear in nature and fear being left behind in a fast-paced curriculum (Hill et al., 2021). In our study, students' desire to understand their learning may have contributed to the higher valuing of teacher support and a relaxed class climate to feel safe making mistakes. Typically, mathematics teaching focuses on developing competency and achievement, with less attention to relationships. The impact of positive relationships, especially teacher support, on overall wellbeing, school belonging, and academic achievement are well recognised (e.g., Kern & Wehmeyer, 2021). Closer attention to building relationships, especially between teachers and students, may be essential to fulfil student's valuing of mathematical understanding and support their MWB.

IMPLICATIONS & CONCLUSION

The first step to building wellbeing in classrooms is to make wellbeing visible (Waters, 2021). A central aim of this study was to make wellbeing visible in mathematics and science by capturing how students communicate the values supporting their wellbeing in these subjects. Making values visible and central to learning can help students to become more engaged, feel calmer and more connected, and improve their (and their teachers') wellbeing (Lovatt et al., 2010). Our findings point to target values to support teachers and students to talk about, assess, and then develop wellbeing across eight broad UVs. Future studies might use methods outlined here to explore student wellbeing in other subjects such as literacy.

Science and mathematics education have strong negativity biases – that is a preoccupation with the failings, anxieties, misunderstandings, 'achievement gaps' and so forth. We suggest a need to incorporate a wellbeing perspective into mathematics and science curricular and pedagogical practices, where students' values and strengths are central to, celebrated, and nurtured in the learning process. This could mean using challenging science/mathematics tasks to teach students about cognitive reappraisal, resilience, and meaningful failure; using project work to encourage collaboration and respect; or identifying students' (and teachers') signature strengths to promote a sense of meaning and accomplishment in mathematics/science. Incorporating wellbeing into the "caught" curriculum, beyond the "taught" curriculum, may make wellbeing knowledge and skills more explicit (White & Kern, 2018), whilst giving teachers a positive language to communicate about wellbeing and thus giving teachers greater agency to make a difference for their students' lives (Kern & Wehmeyer, 2021).

Lastly, given the shortage of mathematics teachers in many countries (English, 2016) our findings suggest science teachers may be a good fit for the mathematics classroom, since their approaches to enhancing students' science wellbeing may also benefit students' MWB development.

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