What Australian Students Say They Value Most in Their Mathematics Learning

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625 primary and secondary students from schools in Melbourne and Geelong completed the WIFI Questionnaire to nominate what they valued in their mathematics learning. A content analysis of students' responses to an open-ended question about what they valued most resulted in a list of 64 unique values. A new, fourth category of values in mathematics education is apparent in this range. *Smartness*, *fun,* and *effort* constituted the top 3 popular values. The four Australian Curriculum mathematics proficiencies are also highly valued by the students. None of the students nominated *achievement* as a value, while it is highly valued by students from countries that perform well in TIMSS or PISA.

Over the last two decades or so, Australian students' performance in school mathematics has been flat at best. In the 20-year period from 1995 to 2015, both Year 4 and Year 8 cohorts of Australian students showed no statistically significant change in mathematics scores in TIMSS assessments (Thomson et al., 2016). Over the 15 years in which six PISA assessments were held from 2000 to 2015, there has been a decline in 15-year-old Australian students' numeracy performance (Masters, 2016). Even more representative of all students is the annual national NAPLAN assessments; numeracy performance at all assessed year levels remained flat in the ten years from 2008 to 2017 (ACARA, 2016a). This situation is not good news, given that millions of dollars had been invested in mathematics and numeracy pre-service and in-service professional development, and also in education research into mathematics pedagogy. Some may feel that the actual situation is worse, given that an increase in migrant students from countries with strong mathematics performance might have pushed up Australia's numeracy performance (Jerrim, 2014).

Australian students' mathematics performance shows little improvement despite years of research, interventions and policies highlights the complexity of the issue, and hints at the existence of variables which might not have been examined yet. The mathematics education research methodology around the world has traditionally been informed by education psychology theories and frameworks, with affective studies contributing to a richer understanding of learning and teaching much later. Then there was the 'social turn' (Lerman, 2000) in the new millennium. Most recently, studies which make use of conative variables such as motivation, mindsets and values (see Goldin et al., 2016) add another dimension to our understanding of the roles of reasoning and feeling in the context of teaching and learning mathematics.

This paper reports on Australia's participation in an international research study which focuses on this conative aspect of mathematics education, in particular, what students value in their mathematics learning. The research study is called 'What I Find Important (in mathematics learning)' [WIFI]. An early aim of the study has been to design and validate a questionnaire with which students' valuing in mathematics learning can be assessed. This WIFI questionnaire serves as a tool to map out attributes of mathematics learning which students in the last two years of primary schooling and the first two years of secondary schooling find important, that is, value. To date, more than 18,000 students from 14 countries/economies have filled out this questionnaire.

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In particular, we report here on a part of the WIFI study, in which we aim to find out what students in Australia nominate as the most important value in mathematics education, as revealed through their responses to an open-ended contextualised survey item.

The Conative Dimension of Learning

Cognition, affection and conation are widely regarded (see Reitan & Wolfson, 2000) as the three fundamental dimensions of mental functioning. Conation refers to

> the ability to focus and maintain persistent effort in order to achieve maximal production in performance of a task—in a sense, the ability to apply maximal intellectual energy to the task at hand, to work with continued efficiency and speed, and to achieve as much effective production as possible. (Reitan & Wolfson, 2000, p. 444)

In this sense, learning convictions or values constitute one of the conative variables, since the drive they provide the individual with would allow him/her to focus and to devote him/herself to 'get the job done'. In the context of this research study, what a student values in his/her mathematics learning gives him/her the drive and motivation to learn mathematics well. This 'want to learn' would position the student in the optimal conditions to draw on his/her cognitive skills and affective dispositions to acquire, understand and apply mathematical knowledge and skills.

Mathematical and Mathematics Educational Values

In mathematics education,

> valuing refers to an individual's embrace of convictions which are considered to be of importance and worth. It provides the individual with the will and grit to maintain any 'I want to' mindset in the learning and teaching of mathematics. In the process, this conative variable shapes the manner in which the individual's reasoning, emotions and actions relating to mathematics pedagogy develop and establish (Seah, 2018, p. 575).

Bishop (1996) categorised the values that might be espoused in mathematics classrooms into three groups, namely, mathematical (learning convictions exemplified by the subject, e.g. *rationalism*), mathematics educational (learning convictions exemplified by the mathematics learning process, e.g. *technology*), and general educational (learning convictions embedded in school education, e.g. *creativity*). This range suggests that many learning convictions are espoused through different aspects within mathematics lessons. Yet, are these the only categories of values in the mathematics classroom?

These convictions/values are important in the learning process, in that they inform a learner's choices and decision-making during the process, demonstrating the conative nature of these values. In this regard, we are interested in understanding how students' learning convictions/values regulate their mathematics learning processes, support (or hinder) the use of cognitive skills and affective states, and thus, play a role in defining student performance. Through our participation in the WIFI study, we aim to understand what Australian students value in their respective mathematics learning, and how these might be similar and different from their peers in other participating countries/economies in the study, such as Ghana, Hong Kong, Japan, New Zealand and the United States of America. The assumption is that if we can better support the development of positive valuing amongst learners, then they are better able to engage, focus and persist when drawing on their cognitive skills and affective dispositions to learn mathematics more effectively.

Research Methodology

Research Participants and Design

We offered the WIFI questionnaire to primary and secondary schools in the state of Victoria, Australia. Seven schools in Melbourne and Geelong responded to the call for participation. Melbourne and Geelong are the two largest cities in Victoria and are also the second and 12th largest cities by population in Australia in 2017. The cities have a combined population of 4.9 million residents then, encompassing diverse ethnicities and nationalities. Years 5, 6 and 9 students from the seven schools were subsequently invited to take part voluntarily. We received a total of 625 questionnaire returns.

The WIFI study adopts the questionnaire method because it aims to collect values data from a large number of participants in a quick and efficient manner. Until then, data from which values in mathematics education were interpreted were collected via lesson observations and interviews (FitzSimons, Bishop, Seah & Clarkson, 2001), or through content analyses of artefacts such as students' drawings (Seah & Ho, 2009) and photographs (Tan & Lim, 2013). We anticipate a large-scale quantitative study such as WIFI would generate insights about values that have greater external validity and generalisability.

The WIFI questionnaire is composed of three sections that assess students' values in different ways. Section A lists 64 classroom practices and students indicate the extent to which they find each one important on a 5-point Likert scale. Section B presents 10 value continua with opposing values (e.g. *process* vs *product*) and students indicate along each continuum their preference between each set of opposing values. Section C invites students to write down what they valued (items 77-79) as opposed to the earlier sections that restrict students' responses to pre-determined values. Specifically, students responded to an open-ended question with a contextual scenario (see Figure 1).

For this paper, item 77 of Section C constitutes the data source. Students write down written responses for what they believe to be the most important for doing well in mathematics. The second and third most important components are written in item 78 and 79, which are not studied in this paper.

Data Analysis

The 625 responses collected were analysed using the software 'Stata version 13' by StataCorp. This included 87 empty responses that accounted for 14% of the total responses. The frequency count included 424 unique responses and the top three unique responses, 'knowledge', 'effort' and 'brain' had 11, 9 and 9 counts respectively.

We used a four-step text analysis process to allocate responses into different value groups. In the raw data, responses that differed in spelling, capitalisation and word length were treated as separate entries. For example, 'brain', 'Brain' and 'Brains' were treated as three unique responses. The four-step process identified responses such as these that convey the same message and allocated them to the same group.

First, we identified the top 30 responses based on frequency count. We set the minimum frequency as the 30th most frequent response because it provided an adequate number of distinct responses without over-sorting latter responses unnecessarily. If we increased the minimum frequency to a higher number, such as top 50 responses, responses in the lower frequency groups would initially be sorted into separate groups at step one, and reallocated into higher frequency groups in subsequent steps. For example, 'knowledge' was the most frequent response, while 'knowledge about' was the 34th most frequent response. The latter low frequency response would remain a separate group until step four where we checked and re-allocated responses in the top 50 responses.

Section C

Imagine that we are going to produce a magic pill.
Anyone who takes this magic pill will become very good at mathematics!

What will you choose to be the **top 3 main ingredients** of this magic pill? (Be imaginative, this main ingredient can be something we can touch and see, or something we can feel but cannot see, for examples)

77. Most important ingredient:

Figure 1. Open-ended item in the WIFI Questionnaire.

Second, for each word in the top 30 responses, we conducted a search for this word in the remaining responses. That is, those responses that were not in the top 30 by frequency. For example, while the response 'brain' was the third most frequent response, the response 'Einstein's brain' occurred only once, and so it was not in the top 30. Our codebook allocated both responses to the same group. If the top 30 response was a phrase rather than a word, we searched for the entire phrase in the remaining responses. If a response could be allocated to more than one group, it was allocated to the group with the higher frequency. For example, the response 'Effort and knowledge about maths' was allocated to the same group as 'knowledge' rather than 'effort', because 'knowledge' was the more common response.

Third, we searched in the remaining responses for expressions that were similar to the groups formed in step 2. For example, the response 'inteligents' (sic.) was allocated to the same group as 'intelligence'. We identified these responses using Levenshtein distance. Levenshtein distance calculates the number of edits needed to change one written response to another. Each edit adds 1 Levenshtein distance. These edits include adding, removing or changing letters. For each of the top 30 responses, we calculated the Levenshtein distance between that response and all remaining responses. We ignored responses that contain 3 or fewer letters. If a top 30 response and a remaining response had a Levenshtein distance of less than 4, then the remaining response was allocated to the same group as the top 30 response.

94 unique responses (i.e. 22% of the responses) were sorted after the first three steps. We set the maximum acceptable Levenshtein distance at 4 because it provided a good balance between percentage and specificity of responses sorted: A maximum Levenshtein distance of 3 and 5 would have sorted 90 and 122 unique responses respectively.

Fourth and last, we coded the remaining unique responses into existing groups or created new groups to accommodate them, according to the codebook. We developed a codebook contains a list of equivalent phrases for each response. We included Bishop's six mathematical values in this codebook. Responses that have similar meaning can differ greatly in Levenshtein distance. We also checked the responses in the top 30 group and reallocated if necessary. All responses were sorted by the end of this step into 72 groups.

We excluded four words from the four-step data analysis process because they are generic and lack specificity. During the first step, ‘Maths', ‘maths', ‘Math’ and ‘math’ were excluded from being a search word even if they constituted one of the top 30 responses. Since this is a survey about values in mathematics education, it is likely student would have responded about different aspects of mathematics learning and teaching. Therefore, we do not want the data analysis process to produce an enormous value category that is essentially a conglomerate of distinct values. For instance, having a value category that contains ‘maths’, ‘Good at maths’, ‘ability to teach maths’, ‘maths dictionary’ and ‘answers to every maths question’ provides little separation between these very unique values.

Results

The data analysis process described above resulted in the identification of 64 different values, ranging from *smartness* with the highest frequency count of 56, to the ten values with the lowest frequency count where each value was only mentioned once: *assessment*, *discovery learning, elegance, geometry, hands-on activities, learning from mistakes, low pressure, number sense, numbers*, and *respect.* The Appendix lists all 64 values and their frequencies. We expected this diverse range of responses, given that the data originated from 625 individuals enrolled in 7 schools serving a large combined area of some 10,908 square kilometres in the very multicultural and diverse state of Victoria. The data were also collected through an open-ended item, which effectively allowed respondents to nominate any learning conviction.

The diversity of student values in the Australian mathematics classroom is also reflected through the wide range but low frequency of values. None of the 64 values accounted for more than 10% of the total responses. Even the most frequent value, *smartness*, was deemed to be the most important learning conviction by only 56 students, representing just 9.0% of the student sample.

Slightly more than half of the student participants (52.3%, n=327) listed one of the following 15 learning convictions as most important for being good at mathematics: *smartness*, *fun*, *effort*, *nutrition*, *knowledge*, *understanding*, *content knowledge*, *fluency*, *technology, chemical stimulants, recall, problem-solving, algorithm, engagement,* and *relationship*.

Amongst the 64 values identified, a majority of them (73.4%, n=47) are mathematics educational (see Bishop, 1996) in nature, which is in line with observations in mathematics classrooms around the world. Three of the six mathematical values conceptualised by Bishop (1988) were evident, these being *logic, openness,* and *mystery*. There are also three values which would have been categorised as general educational by Bishop (1996): *creativity, honesty* and *respect*. Interestingly, there are ten values nominated by 100 students which did not fit into any of the three categories above, these being *smartness, teaching capability, teacher, wellbeing, ability, wisdom, confidence, will, teacher flexibility,* and *wisdom*. We wonder if these might belong to a new category of values in the mathematics classroom, named perhaps as personality values instead.

Discussion

Primary and secondary school students in Australia value a diverse range of mathematics learning convictions. 64 unique values were identified by students as being the most important to being good at mathematics. Given that any one of these values can make a difference to the quality of learning to one of these students, this diversity demonstrates another dimension of the complexity that teachers face when planning and delivering lessons in Australia, and possibly, in mathematics classrooms everywhere else.

The Australian students surveyed in this study are more likely to be valuing *smartness* than any other attributes in their mathematics learning. We find 9.0% of the 625 students nominated it as being the most important value. If this means that there was a group of students who believed that intelligence plays a more important role than hard work and effort, then we also note that *effort* was the third most popular value amongst the student participants, at 4.8% (n=30).

Fun was the second most valued attribute. 33 students, or 5.3% of the respondents listed fun as the most important component for being good at mathematics. This finding is consistent with earlier Australian studies (e.g. Seah & Ho, 2009) in which students regarded *fun* as one of the most prominent attribute of mathematics learning. To some degree, this may reflect the Australian mathematics classroom culture in which teachers are often found to introduce fun activities and tasks (including software programs such as Mathletics) in order to maintain students' engagement, and/or to regain that from the other students.

Nutrition and chemical stimulants were the 4th and 10th most valued attributes by the students, accounting for 4.5% (n=28) and 2.6% (n=16) of the responses respectively. The popularity of food-related attributes could be due to extensive food-related initiatives launched by the state and federal governments within the last decade. For example, Victoria launched a healthy canteen initiative in 2012 that encouraged schools to serve nutritional meals in school canteens and develop curriculum that promote healthy eating. Interestingly, 56% of the 16 'chemical stimulant' responses are likely laced with the Australian sense of humour. 9 of these 16 responses listed an illicit drug or serious medication. This is hopefully influenced by Australian teenagers' sense of humour rather than the students actually believing that these pharmaceutical substances have any impact on mathematical learning.

The four mathematics proficiencies – that is, reasoning, understanding, problem solving, and fluency – in the latest Australian Curriculum (ACARA, 2016b) can be regarded as learning convictions as well. In this regard, we note that all four are already highly valued by students in Australia, being the 6th (*understanding*), 8th (*fluency*), 12th (*problem-solving*), and 17th (*reasoning*) most popular 'most important value' nominated by the student participants. Looked at this another way, 9.9% (n=62) of the students would have nominated any one of these four mathematics proficiencies.

While *achievement* is highly valued by mathematics students of similar age groups in East Asian countries/regions (Zhang, Barkatsas, Law, Leu, Seah, & Wong, 2015), this learning conviction does not appear to be as highly valued in the Australian context. *Performance* would have been a value in our list that came close to *achievement*. Yet, a check of what the 6 students wrote confirmed that their valuing of *performance* still lacks the flavour of not just doing something well, but also of arriving at a set goal in doing so. Out of the 6 responses, 5 were about the importance of being 'good at mathematics', while the last one referred to 'doing mathematics well'.

Although it is pedagogically and ethically responsible to regard each student as an individual, so that teachers plan lessons to cater to each of his/her students, the reality is that the ability range in any class can be so huge that not all students' learning needs are catered for. While this is not to say that teachers ignore individual student needs, there is perhaps space and room for whole-class planning to assume a more central focus in lesson planning. To this end, a knowledge of what most students value in their mathematics learning – as demonstrated through the findings of this research study – would be very useful for teachers.

Conclusion

625 students in Years 5, 6 and 9 from 6 schools in Melbourne and 1 school in Geelong completed the WIFI Questionnaire. A content analysis of students' responses to an open-ended question about what they valued most in mathematics learning revealed a list of 64 unique learning convictions, of which 15 of them were nominated by slightly more than half of the students. Although 54 of these values could be categorised into mathematical, mathematics educational or general educational values, the other 10 appeared to be of the (teacher/student) personality nature. *Smartness* was the most popular value, but *effort* was also highly valued (third most popular) by the rest of the students. We also note that the four mathematics proficiencies were highly valued by the students; *reasoning* was the only one which was not within the top 15 responses. At the same time, the valuing of *achievement*, an attribute which is often valued in many foreign education systems, is not observed in the Australian responses.

The conduct of this research study was motivated by Australia's essentially flat performance in mathematics and numeracy assessments in the last 15-20 years. The consideration of what students value (and not value) allows us to better understand why relevant cognitive skills and affective dispositions have not been optimised to promote effective and deep learning in mathematics. This conversation can begin now.

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Appendix: List of Values Embraced by Students in Australia

Value	Frequency	Value	Frequency
Smartness	56	Energy	4
Fun	33	Imagination	4
Effort	30	Process	4
Nutrition	28	Fraction	3
Knowledge	21	Computation	3
Understanding	20	Wisdom	3
Content knowledge	19	Practice	3
Fluency	18	Confidence	3
Technology	18	Examples	3
Chemical stimulants	16	Applications	3
Recall	15	Learning aids	3
Problem-solving	15	Will	3
Algorithm	14	Accuracy	3
Engagement	12	Product	3
Relationship	12	Exploration	3
Teaching capability	11	Openness	2
Reasoning	9	Logic	2
Perseverance	9	Honesty	2
Teacher	9	Connections	2
Division	8	Teacher flexibility	2
Teacher explanation	8	Visual explanation	2
Wellbeing	6	Patience	2
Performance	6	Geometry	1
Strategies	5	Learning from mistakes	1
Think	5	Number sense	1
Multiplication	5	Assessment	1
Creativity	5	Respect	1
Individualised learning	5	Numbers	1
Ability	5	Elegance	1
Concept	5	Hands-on activities	1
Mystery	4	Low pressure	1
Algebra	4	Discovery learning	1