What Australian Primary School Students Value in Mathematics Learning: A WIFI Preliminary Study

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Grades 5/6 students in Melbourne reported the valuing of *achievement*, *open-endedness, relevance, humanism, ICT,* and *openness* most in mathematics learning. Although prior research suggested that students in East Asia valued *achievement* most as well, there was an observed difference in the nature of this valuing in Australia. Knowledge of what students value reveals the pedagogical potential of values, and also allows teachers to identify values related to effective mathematics learning. Values alignment facilitates further work with these values.

The latest results of the Trends in International Mathematics and Science Study [TIMSS] (Mullis, Martin, Foy & Arora, 2012) and Programme for International Student Assessment [PISA] (Thomson, de Bortoli & Buckley, 2013) indicate that there has been no significant improvement in Australian students' attainment in school mathematics at both primary and secondary levels, whereas the mathematics performance of students in some other countries had caught up with and/or overtaken that of their peers in Australia. It is thus important to review how emergent educational research findings and existing best practices in mathematics pedagogy in Australia might efficiently be adopted in classrooms.

In this context, we argue that the volitional aspect of learning and teaching is a key approach to facilitating effective lessons, and it can complement cognitive and affective approaches to pedagogy. In particular, the volitional variable of values and valuing contributes to the nature and strength of the willpower of students in their learning experiences. This paper reports on the initial stage of the Australian involvement in an international study that aims to investigate what students find important and value in their respective mathematics learning experiences. This study, named *What I Find Important (in mathematics learning)* [WIFI], has research teams based in 10 other regions, such as mainland China, Germany, Greece, Hong Kong, Japan, Scotland, Sweden and Thailand.

The role of volition in general, and of values in particular, in regulating action and behaviour will thus be discussed first to provide a theoretical context for the study being reported here. The methodology adopted to collect relevant data will then be presented. This will then be followed by a report of results and findings. Implications for teaching practices will be offered at the end of this paper.

Volition and Student Actions

The effectiveness of a student's (mathematics) learning is determined largely by the decisions s/he makes, and the subsequent actions chosen, with regards to engaging with the subject and with the associated pedagogical activities. Students are agentic in adopting or resisting discursive positions in their interactions with their teachers, peers and parents.

Yet, student actions such as committing to understand the relationship between areas and perimeters, or engaging in mathematical discussions with their peers in class, may not be regulated by cognitive and affective factors alone. A student may know the benefits of peer discussions (cognition) and may also possess positive beliefs about these benefits

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(affect), yet the commitment, engagement or priority may or may not be strong enough for this student to want to learn through peer discussions or groupwork, to find it importantly enough, and to value it sufficiently, especially when faced with obstacles. Thus, decisions and subsequent actions are also functions of willpower and of volition.

The interaction amongst cognition, affect and volition to guide decisions and actions is not new knowledge. For example, the research area of cultural neuroscience has examined how these three aspects shape and are shaped by one another (see, for example, Chiao & Ambady, 2007). Another group of researchers (e.g. Berlin, 2011) associates cognition, affect and volition to different neural structures. Here, Westerners had been observed to focus more on the object than on context when compared to East Asians, whereas the East Asians exhibited greater context-focussed processing than their counterparts in the West (Gutchess, Welsh, Boduroglu & Park, 2006).

Values as a Volitional Variable

Values constitute one of the volitional variables, in that valuing something provides one with the will to behave and act in ways which reflect what is being valued. Here, we adopt the definition in Seah and Andersson (in press):

> Values are the convictions which an individual has internalised as being the things of importance and worth. What an individual values defines for her/him a window through which s/he views the world around her/him. Valuing provides the individual with the will and determination to maintain any course of action chosen in the learning and teaching of mathematics. They regulate the ways in which a learner's/teacher's cognitive skills and emotional dispositions are aligned to learning/teaching in any given educational context.

The importance of working with values in mathematics educational research extends beyond its interaction with cognitive and affective factors in regulating learner actions. Values are relatively internalised and stable within an individual or a culture (Rokeach, 1973), which highlights the potential of cultivating or promoting of values that facilitate student engagement, understanding and/or performance in mathematics learning.

We are thus interested in understanding the nature of what are being valued by students in the attained curriculum level of school mathematics learning and teaching. This knowledge will not only provide us with a glimpse into the values that are internalised by students in their respective mathematics education experiences, but may also be useful to help us explore any association of particular values with quality mathematics learning.

Researching Values with the WIFI Questionnaire

Despite the use of questionnaires in other areas of study (e.g. the Portrait Values Questionnaire in Schwartz, Melech, Lehmann, Burgess, Harris & Owens, 2001), educational research has been assessing values through methods such as observations and interviews (e.g. Court, Merav & Ornan, 2009; Lin, Wang, Chin & Chang, 2006). The methodology for the WIFI Study was designed to facilitate practitioners' assessment of values without the relatively lengthy time needed for data collection, and without these practitioners feeling that specialised researching skills are needed in order to make observations and/or to conduct interviews. Thus, drawing on the findings of previous research of values and valuing in mathematics education (e.g. FitzSimons, Seah, Bishop & Clarkson, 2000), the WIFI Questionnaire was constructed and subsequently validated cross-culturally for use by the various member teams in the Study.

Another reason for the use of the questionnaire method in the WIFI Study was the affordance for large-scale data collection and sophisticated quantitative analyses. This method would better allow for generalisations of what students value to be made at the community/cultural levels, the difficulty of which would understandably be a limitation of previous (values) research incorporating the observation and/or interview methods.

The WIFI Questionnaire gathers information through three question types across three sections. Section A is made up of 64 five-choice Likert scale items, each of which poses the respondent with a (mathematics) learning activity (e.g. item 3: small-group discussions), to which the respondent indicates if s/he regards it as absolutely important, important, neither important nor unimportant, unimportant, or absolutely unimportant.

Section B of the WIFI Questionnaire is made up of 10 slider rating scale items. Each item presents the respondent with a pair of opposing values at the ends of a line (e.g. item 68: 'Leaving it to *ability* when doing maths' vs 'Putting in *effort* when doing maths'), to which the respondent indicates on the line his/her relative valuing between the two orientations.

The last section of the WIFI Questionnaire was designed to identify student values which might not have been covered in the previous sections. Thus, the four items here are open-ended, and contextualised in a scenario. Only the analysis of Section A will be discussed in this paper.

Data Sources

This paper reports on the preliminary study phase of the Australian participation in the international WIFI Study. While the main intention of the preliminary study has been to assess the extent to which the WIFI Questionnaire can be responded to by students in Australia without methodological issues, this paper will report on the findings that evolved as the result of analysing the collected data.

Pioneer Primary School (pseudonym), a Melbourne suburban Catholic primary school, was the site of the preliminary study. Approximately 95% of the student population was identified by the school as being English as an Additional Language students and about half of the students in the school qualified for Education Maintenance Allowance.

An indication of the school's mathematics performance is through the comparison of the Grades 3 and 5 students' mean results with the state and national mean scale scores in the annual, Australia-wide NAPLAN assessment exercise. In Grade 3, the school's mean score is similar to the national mean (396.9) (ACARA, 2013) and below that of the state's (409.4). Amongst the Grade 5s, the school's mean score is below that of both the national mean (485.9) and the state mean (493.1).

Results

Principal Components Analysis (PCA)

A Principal Component Analysis [PCA] with a Varimax rotation was used to examine the questionnaire items. The significance level was set at 0.05, while a cut-off criterion for component loadings of at least 0.45 was used in interpreting the solution. Items that did not meet the criteria were eliminated. The analysis yielded six components with eigenvalues greater than one, which accounted for 45.65% of the total variance. Due to space constraints, only Components 1 and 4 are displayed in Table 1 below.

Table 1
Components 1 and 4 of the Rotated Component Matrix

Components	1	4
Q28 KnowingTheTimesTables	0.816	
Q51 LearningThroughMistakes	0.774	
Q44 FeedbackFromMyTeacher	0.762	
Q14 MemorisingFacts	0.736	
Q56 KnowingTheStepsOfTheSolution	0.727	
Q42 WorkingOutTheMathsByMyself	0.717	
Q54 UnderstandingConceptsProcesses	0.715	
Q62 CompletingMathematicsWork	0.705	
Q58 KnowingWhichFormulaToUse	0.694	
Q63 UnderstandingWhyMySolutionIsIncorrectOrCorrect	0.675	
Q49 ExamplesToHelpMeUnderstand	0.636	
Q30 AlternativeSolutions	0.613	
Q43 MathematicsTestsExaminations	0.606	
Q55 ShortcutsToSolvingAProblem	0.606	
Q46 MeAskingQuestions	0.576	
Q38 GivenAFormulaToUse	0.569	
Q22 UsingTheCalculatorToCheckTheAnswer	0.537	
Q1 Investigations	0.532	
Q47 UsingDiagramsToUnderstandMaths	0.522	
Q41 TeacherHelpingMeIndividually	0.514	
Q13 PractisingHowToUseMathsFormulae	0.497	
Q32 UsingMathematicalWords	0.496	
Q35 TeacherAskingUsQuestions	0.469	
Q17 StoriesAboutMathematics		0.778
Q10 RelatingMathematicsToOtherSubjectsInSchool		0.734
Q11 AppreciatingTheBeautyOfMathematics		0.691
Q61 StoriesAboutMathematicians		0.684
Q6 WorkingStepbystep		0.527
Q29 MakingUpMyOwnMathsQuestions		0.474

Analysis of Variance

The existence of statistically significant differences between each of the six components derived from the PCA on the one hand, and grade level (Grades 5/6) or gender on the other, was investigated by using univariate ANOVAs. The dependent variables (DIs) were the 6 components derived from the PCA and the independent variables (IVs) were grade level and gender, respectively

We have significant univariate main effects only for component 4, at the 0.001 alpha level:

Component 4 (C4) : $[F(1, 65) = 15.775, p < 0.001, \eta^2 = 0.211]$

No gender statistically significant differences were identified for any of the six components used in the analysis.

Analysis

Relating each of the components to a value label is not a precise science, and the subjective nature of this exercise is acknowledged. Consultations with colleagues and with staff of the participating school increased the validity of the interpretations made in according value labels to the 6 components. Thus, for the Grade 5/6 students of Pioneer Primary School, the questionnaire responses indicate their valuing of *achievement, open-endedness, relevance, humanism, ICT,* and *openness*, respectively for components 1 to 6.

The Grade 5/6 students of Pioneer Primary School valued *achievement* the most. A large number of questionnaire items loaded onto this component. In order to achieve in their mathematics learning, the student respondents found it important to know the steps of the solution (item 56), know which formulae to use to arrive at the solution (item 58), and know the multiplication tables (item 28). Time efficiency was a factor here, and the students valued the memorising of mathematical facts (item 14) and access to shortcuts to solving a mathematical problem (item 55). Associated with this is the harnessing of appropriate technologies, where the students valued the use of the calculators to check for the accuracy of computations made (item 22). Yet, the students' valuing of *achievement* in their mathematics learning was also associated with mathematical understanding. They wanted to understand the concepts/processes they were learning (item 54), and they found it important to be given examples to assist them to do so (item 49). The students also needed to understand why their solutions were correct (or incorrect) (item 63), not just that they were correct (or incorrect). In their quest to achieve in their mathematics learning, the students found it important that their teachers posed them questions (item 35), while providing individual help (item 41) and feedback (item 44). On their part, the students understood the importance of completing mathematics work (item 62), working out the mathematics by themselves (item 42), and engaging in practice (item 13). The students saw the importance of tests and examinations (item 43), and understood that they might need to learn from mistakes (item 51).

The other 5 components (values) that were observed for Pioneer Primary School can be similarly understood by examining the items that loaded onto each of the values.

Discussion

The 63 Grade 5/6 students of a Catholic school in suburban Melbourne, Australia valued in their mathematics learning the following convictions: *achievement, open-endedness, relevance, humanism, ICT* and *openness*. No statistically significant differences were found between male and female students. There were no statistically significant differences in five of the six components between the Grades 5 and 6 students, except in the valuing of *humanism*, where the Grade 6 students emphasised it more than their peers one grade lower. Given that this group of student respondents were involved in a preliminary study for the international WIFI Study, the sample size was not large.

Furthermore, in the absence of follow-up interviews with the respondents, much of the sense-making would be made from the outsider's (Bartunek & Louis, 1996) perspective. Thus, the results will be interpreted with these restrictions in mind, and the reader is cautioned against making generalisations to the wider Australian mathematics education scene.

The students' valuing of *achievement* more than any other conviction was not a surprise to the school. Apparently, the high proportion of refugee migrant families in the school community had meant that many of its students were growing up in a new country, learning the importance of striving hard to create a better living condition for themselves or for their families. Though the students might still be young, their families' emphasis on *achievement* in their new homeland would likely have been inculcated in their psyche. Coupled with the emphasis of literacy and numeracy in schooling outcomes in Australia, as well as the students' impending entries into secondary schools, it might be expected that the students found it important to do well in mathematics, thus valuing *achievement*.

On the other hand, the school was surprised that *open-endedness* was valued so highly amongst its students. This conviction was very much emphasised in the school's curriculum, and students were often encouraged by their teachers to embrace the fact that there can be multiple correct answers to any given (mathematics) problem. However, the students were often found complaining about mathematics questions not having just one correct answer, and it seems that ironically, multiple possible answers had led students to feel more insecure about their own solutions. Yet, despite this expressed dislike for, or discomfort with, *open-endedness* amongst the students' feedback, they appeared to find it an important aspect of their mathematics learning.

How does this set of Australian data compare with international WIFI data? In particular, given that students in East Asia have been leading the TIMSS and PISA performance rankings, how did the valuing by this group of Australian students differ from that of their peers in East Asia?

For this purpose, we refer to Seah, Zhang, Barkatsas, Law & Leu (in press), arriving at Table 2 which lists the top 6 convictions valued by the students in Pioneer Primary School and in East Asia. The East Asian data had been collected in 2012-2013 from 1,386 Grades 5 and 6 students in Mainland China, Hong Kong, and Taiwan. All data were gathered with the same WIFI Questionnaire, although the instrument was translated into the Chinese language when it was administered in the three East Asian regions.

Table 2
Students' Most Valued Convictions in Australia and in mainland China / Hong Kong / Taiwan

Australia	Mainland China / Hong Kong / Taiwan
Achievement	Achievement
Open-endedness	Relevance
Relevance	Practice
Humanism	Communication
ICT	ICT
Openness	Feedback

The students in Australia and in East Asia valued *achievement* most, and they also valued *relevance* highly. ICT was the third commonly-valued conviction in mathematics learning in Australia and East Asia, ranking fifth in both sets of data. Whereas primary school students in East Asia also valued *practice*, *communication* and *feedback*, these are different from the other three values subscribed to by their peers in Australia. Indeed, the valuing of *practice*, *communication* and *feedback* can be considered to be supporting the valuing of *achievement*. That is, to do well in mathematics, it is important to practise, to discuss with peers and teachers, and to receive feedback from them.

On the other hand, in the group of participating Australian students, their valuing of *open-endedness*, *humanism* and *openness* appeared to be related to the nature of school mathematics. Whereas these students' valuing of *achievement*, *relevance* and *ICT* might be perceived as fostering mathematical understanding, competency and performance, the other values amongst the 6 most valued convictions expressed a concern for ways in which mathematics related to society and culture. For example, the valuing of *humanism* (component 4) in mathematics emphasises how the discipline is a human construct, with its own stories about mathematics (item 17) and mathematicians (item 61). Furthermore, mathematics problems/questions need not be existing out there, but may be posed by any individual (item 29).

Does this observed focus on relationships and a correspondingly less emphasis on competition in the Australian data signal a more feminine orientation amongst Australian primary school students when compared to their peers in East Asia? That is, in Hofstede's (1997) language, were students in East Asia more masculine oriented in that what were regarded as important to them were driven by competition, achievement, and success? Students in Australia, on the other hand, possessed values that suggested a relative emphasis on relationships, quality of life, and care. After all, the school's vision statement reflected values of faith and love, the listing here of which is restricted by research ethical concerns.

Implications

Knowledge of what students value in mathematics learning is important in that it allows for these values to be evaluated by teachers and educators for their pedagogical potential, at the same time allowing researchers to explore and identify values that might be associated with effective mathematics learning. The small Australian sampling pool has suggested primary school students' valuing of *achievement, open-endedness, relevance, humanism, ICT* and *openness*. While there are similarities to the convictions valued by their peers in East Asia, the nature of the common valuing (e.g. of *achievement*) is different, given the difference in cultural settings. No significant gender difference in the students' valuing of was found, whilst the Grade 6 students appeared to value *humanism* more than their Grade 5 peers.

The extent to which the students' values are aligned with the school or community values is crucial to optimising their mathematics teaching and learning experiences. It is argued by Seah and Andersson (in press) that values alignment holds the key to effective mathematics teaching and learning. Teacher recognition of what their students value in mathematics learning allows for particular valuing to be introduced or further supported at all levels of the curriculum, whether it is intended, implemented or attained. Identifying and inculcating these values may well complement existing best practices from the cognitive and affective approaches in sustaining engagement, deepening understanding, strengthening performance and cultivating mathematical habits of mind amongst students.

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