Male Students' Perspectives Concerning the Relevance of Mathematics – Pilot Study Findings

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A pilot study was conducted with Year 10 males (N = 154) preparing to make their senior mathematics subject choice. Survey data revealed that students did not understand the different dimensions of relevance of mathematics. Additionally, a statistically significant difference in the level of agreement concerning relevance was identified between students choosing Mathematics A and those choosing both Mathematics B and C. Students choosing both Mathematics B and C perceived mathematics as relevant for facilitating their career pathway, while Mathematics A aspirants acknowledged the relevance of mathematics was less influential, reporting their choice was guided by their mathematical ability.

For an economy to be productive and competitive, it is reliant upon individuals who are scientifically and technologically literate. The discussion paper, *Towards a 10-year plan for Science, Technology, Engineering and Mathematics (STEM) education and skills in Queensland* (Department of Education Training and the Arts, 2006) reports that, an increasing demand for professional, trade and technical occupations exists in STEM related careers. However, the evident decline in students pursuing high levels of post-compulsory mathematics in Queensland schools has reduced the pool of mathematically capable students undertaking tertiary studies in mathematics or scientific areas. It is therefore necessary to explore and identify what influences students' choice as to whether they participate in high levels of mathematics.

Studies have explored the decline in the number of students participating in mathematics subjects in general, and a variety of findings have been presented. Reasons identified include student disaffection (Nardi & Steward, 2003), students' attitudes (Brown, Brown & Bibby, 2008), and the influence of peers, parents and teachers (Ma, 2000). However, the research literature is beginning to provide increasing evidence that the relevance students' associate with mathematics influences their participation and engagement. In the Australian context, research has been conducted examining the propensity of Year 12 students across ten South Australian schools to study mathematics currently and after completing Year 12 (Brinkworth & Truran, 1998). This study revealed that the *need* for mathematics as a prerequisite to further study was the most noteworthy reason influencing students' current and post-school participation in mathematics (Brinkworth & Truran, 1998). More recently, a study has focused on reasons why capable students were not choosing higher-level senior mathematics (McPhan, Morony, Pegg, Cooksey & Lynch, 2008). This study explored the perspectives of 15-year-old students and identified that one of the explicit influences that affected students' choice was the perception they associated with the *usefulness* of higher-level mathematics (McPhan, Morony, Pegg, Cooksey & Lynch, 2008). These findings echo past research (Brinkworth & Truran, 1998) in that the usefulness of higher-level mathematics was perceived as its value as a prerequisite for entry into post-secondary level courses, especially tertiary courses with a high tertiary entrance score. Additionally, research reveals that the common terms used by students to describe relevance of

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mathematics include *need* or *useful (ref)*. However, when considering relevance, terms such as *need* or *useful* reveal a more nuanced meaning.

More recent studies have moved beyond looking at the difference between *need* and *usefulness* to consider the relevance of mathematics. Sealey and Noyes (2010) conducted research and reported results from focus group interviews at three contextually different schools located in the United Kingdom. Amongst their findings was the recognition that students from different schools attached different relevance to mathematics. These results provided a framework that categorised relevance as having three different dimensions. The first dimension, acknowledged that mathematics had a useful purpose identified as *practical relevance*. In this sense, students perceived mathematics as a tool used for performing basic calculations or solving simple problems in day-to-day life. The second dimension recognised that mathematics has transferable potential or *process relevance*. In this regard, students perceived that mathematics provided skills that facilitated conceptualising and solving problems in different contexts. The third dimension established that mathematics provided exchange value or *professional relevance*. In this dimension students sensed that mathematics enabled their tertiary trajectory and assisted them to fulfil their career ambitions. Little is known about the relationship between practical, process, and professional dimensions of relevance or the impact they have on subject choice. This paper examines and presents initial findings concerning Year 10 male students' perceptions of relevance as they consider their Years 11 and 12 mathematics subject choice by providing ratings for Likert items and responses to open-ended questions presented in a survey instrument.

Context

This paper reports on an element of a larger study conducted in Queensland that explored the decline in participation in Mathematics B, and Mathematics B and C among male students in Years 11 and 12. The results presented are from the pilot study conducted at Willow College (pseudonym). In Queensland, while studying mathematics is not compulsory in Years 11 and 12, the majority of students participate in either Mathematics A, Mathematics B, or Mathematics B and C. Mathematics A is an increasingly popular subject that provides students with suitable preparation for further study and training in technical trades, hospitality, and administrative roles and enables students to engage in tertiary studies where mathematics requirements are moderate. Mathematics B provides students with preparation for tertiary studies in subjects, especially in the areas of science, engineering, information technology, and mathematics. Its predominant focus is on calculus and algebra utilised in mathematical contexts. Mathematics C is a subject studied in conjunction with Mathematics B and is designed to provide a greater level of preparation for students seeking to engage in tertiary studies where mathematics requirements and its predominant focus is on more abstract mathematical concepts such as complex numbers and matrices (Queensland Studies Authority, 2008).

Method

Participants

Willow College was purposely selected for the pilot study as it shared comparable demographics with the research school, including a male only educational context, a non-selective student enrolment policy, and an ethos based on the vision of the same Christian founder. Furthermore, the Index of Community Socio-Educational Advantage (ICSEA) provided for schools throughout Australia by the Australian Curriculum, Assessment and

Reporting Authority (ACARA), established that Willow College (M = 1023) and the research school (M = 1039) were statistically similar in terms of the socio-economic standing of their respective communities (M = 1000, SD = 100). The entire Year 10 cohort (N = 154) ranging between the ages of 14 - 16 years (M = 14.84) completed the pilot survey instrument, representing a cross-section of mathematical ability, achievement, and experiences.

Pilot Survey Instrument

Two sources were used to develop the pilot survey instrument namely the current research literature and the focus group interviews with staff. First, the literature was examined to identify themes that related to students' participation in mathematics and mathematics subject choice. The themes that emerged were school culture (MacNeil, Prater & Busch, 2009), learning mathematics (Philipp, 2007), mathematics teaching (Stipek, Givvin, Salmon, & MacGyvers, 2001), and perceptions of relevance (Chouinard & Roy, 2008). Second, the survey instrument was informed by the results of focus group interviews conducted at the research school to gather contextual knowledge regarding influences affecting students' participation in Mathematics B, and Mathematics B and C. These interviews were conducted with four groups of purposely selected teachers (N = 8) that either taught Year 10 students mathematics (n = 5), counselled Year 10 students preparing to make their senior mathematics subject choices (n = 1) or had curriculum leadership roles (n = 2) at the school. A schedule of questions for each focus group interview was prepared from themes identified in the literature and through collaboration with expert academic staff. The duration of the interview was 45 minutes and responses to questions were audio-recorded and then transcribed for qualitative analysis facilitated by using software, Atlas.ti.

Themes that emerged from analysis of the focus group interviews confirmed concepts and issues identified in the literature. Teachers identified that university prerequisites, teacher pedagogy and teacher experience influenced students' participation in Mathematics B, and Mathematics B and C. However, an analysis of teacher data revealed that based on their perceptions, other elements impacted on students' participation in mathematics, for example commitments outside the school, access to knowledge concerning careers and the unique culture of the school. Together, themes from the literature and focus group interviews combined to inform the construction of the pilot survey instrument.

The instrument consisted of three sections. The first section presented 15 demographic questions inviting the participant to provide their age, cultural background, levels of mathematical achievement and career aspirations. The second section consisted of 47 Likert items distributed across five dimensions. The dimensions used to explore the decline in male students' participation in Mathematics B, and Mathematics B and C were: (1) school culture, 10 items; (2) learning mathematics, 13 items; (3) mathematics teaching, 9 items; (4) the relevance of mathematics, 7 items; and, (5) other elements impacting on students' senior mathematics subject choice, 8 items. Participants evaluated and provided a response to each item according to their level of disagreement or agreement. A symmetrical, five-point rating scale was provided for each item: 1 – Strongly disagreed; 2 – Disagreed; 3 - Unsure; 4 – Agreed; or 5 – Strongly agreed with an item. The third section of the survey invited students to write responses to eight open-ended questions to further explore themes identified in the literature.

Data Collection

The survey was conducted at Willow College in the first week of Term 3, 2011. Six Year 10 mathematics teachers administered the survey to each of their classes. Using the instructions that were provided all students in the cohort completed the survey anonymously in approximately 20 minutes, under examination style conditions. At the completion, teachers returned surveys to the Principal and were collected by the researcher. Overall, a small number of questions in the demographics and second sections were not attempted or were completed with errors by some students and these were accommodated in the statistical analysis.

Analysis and Results

Analysis of the pilot study data was conducted in stages. First, responses from the demographic and second section of the survey were checked for possible errors and missing data and consideration was given to how these issues would be handled in the data entry stage. Second, students' responses were coded by assigning numerical values to each possible response. Third, the data were entered in the Statistical Package for the Social Sciences (SPSS) software to conduct statistical analysis. A Principal Component Analysis (PCA) with orthogonal rotation was conducted on the items associated with each section of the survey (varimax). This statistical technique (factor analysis) was applied to identify whether correlations existed between chosen sets of variables. Figure 1 provides the scree plot that illustrates the distribution of factors associated with items in the relevance dimension.

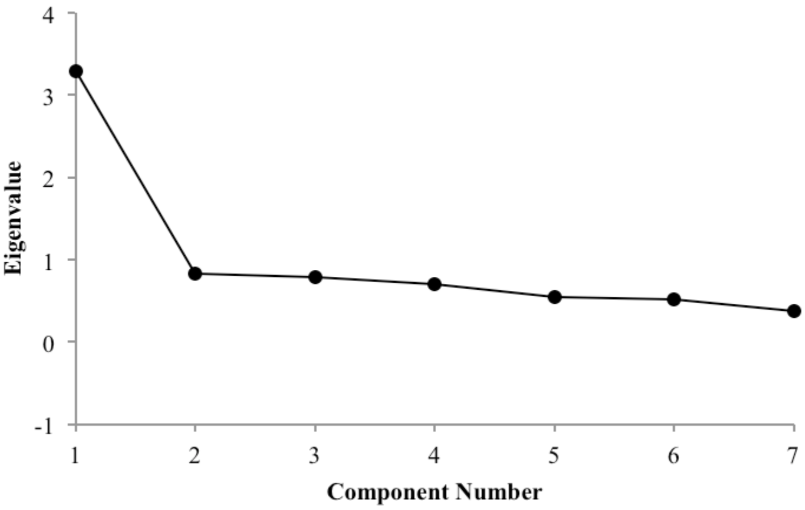

Figure 1. Scree plot presenting eigenvalues for a seven-factor solution.

An initial analysis was run to obtain eigenvalues for each component in the data. Using Kaiser's (1960) criterion, only factors in the scree plot with an eigenvalue greater than one were retained. In this analysis, one factor was identified that accounted for 47% of the total variance. The analysis also provided a rotated factor matrix with loading for all relevance items. Table 1 presents the factor loading after rotation and the associated dimension of relevance for each item.

Table 1.
Dimensions of Relevance, Items and Associated Factor Loadings.

Dimensions	Items	Factor
Practical	I have learnt how mathematics is used in society	0.76
Professional	Careers involving mathematics are highly regarded in society	0.73
Process	Mathematics teaches important problem solving skills	0.70
Professional	Careers involving Mathematics are well paid	0.68
Practical	I use mathematics in my everyday life	0.67
Process	Mathematics assists me in other subjects I study at this College	0.64
Professional	There are many careers that require the use of mathematics	0.62

In order to ascertain the level of agreement in the relevance dimension each student was allocated a mean score for the seven items. Each student's mean score was calculated by aggregating their Likert values for each item in this dimension and dividing this total by the number of items in the dimension. The mean agreement across the participants relevance score was M = 3.812. To examine if this mean level of agreement differed across the subject choice of students at Willow College, three distinct groups of students were selected, namely, students who selected Mathematics A, Mathematics B, or Mathematics B and C for Years 11 and 12. The mean score for the subjects Mathematics A (n = 49), Mathematics B (n = 63), and Mathematics B and C (n = 24) were M = 3.70, M = 3.85 and M = 4.09 respectively, and this indicated that students perceptions towards the relevance of mathematics ranged between ambivalence and strong agreement. Figure 2 presents a graph of the mean scores for Mathematics A, Mathematics B, and Mathematics B and C.

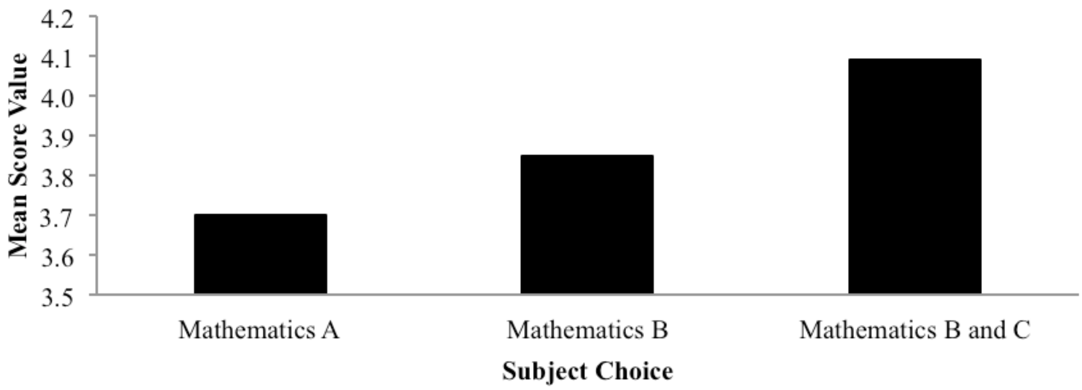

Figure 2. Mean scores calculated from Mathematics A, Mathematics B, and Mathematics B and C students' ratings of relevance items.

A one-way analysis of variance (ANOVA) was performed to ascertain if a significant difference existed between the mean of each group. The post hoc Tukey test revealed a statistically significant difference (p = 0.029) between the level of agreement for students seeking to study Mathematics A and those seeking to study Mathematics B and C. This indicated that students seeking to undertake the most demanding level of mathematics placed higher value on the relevance of mathematics as compared to students choosing the less demanding levels of mathematics. An analysis of the written responses from the third section of the survey provided insights into these differences.

Differences between students' perceptions of the relevance of mathematics when choosing to study Mathematics A, and Mathematics B and C was further explored by examining their responses to two open-ended questions, "*What will influence your final decision regarding the mathematics subjects you choose in Years 11 and 12?*" and "*Explain whether you believe mathematics has a critical role in society*" that focused on the notion of relevance. Student's response to each question was entered into Atlas.ti and themes were identified in their responses. Similar themes were grouped to identify key themes in the data. Student's responses were then identified in terms of the key themes, the results of which were aggregated and converted to a percentage of each subject group. Table 2 presents responses to the first question, "*What will influence your final decision regarding the mathematics subjects you choose in Years 11 and 12?*"

Table 2
Themes Identified by Students as Influencing their Senior Mathematics Subject Choice by Intended Subject Level.

Themes	Mathematics A (%)	Mathematics B and C (%)
University prerequisites	4.1	8.3
My intended career path	34.7	54.2
My mathematical ability	36.7	16.7
Advice from others	10.2	8.3
Unsure	4.1	-
Commitments outside the College	2.0	-
No response provided	8.2	12.5

Data in Table 2 indicates that the highest single contributing factor for students intending to study Mathematics B and C was the professional relevance of mathematics as a means of enabling their desired career path. However, for students seeking to study Mathematics A, the professional relevance they ascribed towards mathematics was markedly lower. The factor that had the greatest influence on Mathematics A students subject choice was their perceptions of their mathematical ability.

The second open-ended question, "*Explain whether you believe mathematics has a critical role in society*" invited students to reflect on their perspectives regarding the usage of mathematics beyond the school context. Students' responses were categorised into themes and presented as percentages in Table 3. The data in Table 3 revealed, when considering dimensions of relevance, students seeking to pursue Mathematics A, or Mathematics B and C held similar perceptions concerning its everyday usefulness. More than twice the percentage of students seeking to study Mathematics B and C as compared to Mathematics A appreciated that mathematics was utilised in variety of occupations. Yet, 25% of students seeking to study Mathematics A were alone in their view that mathematics was not critical, and thus they saw no relevance for mathematics in society.

Table 3
Students' Perspectives of Whether Mathematics has a Critical Role in Society by Intended Subject Level.

Themes	Mathematics A (%)	Mathematics B and C (%)
A requirement for a variety of occupations	20.4	45.8
Everyday usefulness	38.3	37.5
Not critical in society	24.5	-
Yes without justification	10.2	12.5
Unsure	2.0	-
No response provided	4.1	-

In summary, data from the pilot study conducted at Willow College revealed a statistically significant difference between students choosing to study Mathematics A, and Mathematics B and C with respect to relevance (see Figure 2). Mathematics B and C students placed a greater emphasis on the importance of mathematics for their chosen career path than those in Mathematics A (Table 2). These students also recognised that mathematics was highly important across many careers in society. Beyond identifying a basic understanding of the usefulness of mathematics, students' choosing Mathematics A (36.7%) were most concerned with whether they possessed the necessary ability to study mathematics.

Discussion and Conclusion

Three tentative conclusions emerged from the data analysed for this dimension of the pilot study. First, there appeared to be some overlap between the three dimensions of relevance as identified by Sealey and Noyes (2010). This was evidenced by the Year 10 cohort ratings of the survey items in the relevance dimension that resulted in one factor that did not delineate between the practical, process and professional dimensions of relevance. While students did not distinguish between the three dimensions, the nuances associated with each dimension were evidenced in their responses to the open ended questions in the survey. It should also be recognised that this outcome may reflect the limited number of questions that were used to explore this dimension.

Second, the relevance of mathematics and its role in subject choice selection was revealed as statistically different for students selecting to study Mathematics B and C as opposed to students choosing to study Mathematics A. The mean level of agreement to this dimension by three groups of students showed that those seeking to undertake more demanding levels of mathematics assigned a higher value towards the relevance of mathematics in contrast to students choosing less demanding levels of mathematics. When invited to respond to the open-ended question regarding factors that would influence their final mathematics subject choice, Mathematics B and C students identified that they would choose this subject because they were aware of its professional relevance, which would contribute to their post-secondary study prerequisites and career pathways. In contrast, Mathematics A students were more concerned with their mathematical ability that mirrors past research findings (Brinkworth & Truran, 1998; McPhan, et.al., 2008). However, whether it is the most noteworthy element influencing students' current and post-school participation in this subject needs further investigation. Additionally, the results give some insight into the motivation and value that different groups of students associate with studying mathematics. While all students incorporate a dimension of understanding about the future requirement of mathematics for employment, it seems that students studying higher levels of mathematics are more aware of this dimension. Whether this is a consequence of these students choosing careers that have a specific mathematical focus or other influences, such as, home life or in class experiences is beyond the scope of this paper.

Third, for some students, how relevance influences their mathematics subject choice is a secondary concern. Data from the open-ended question, "*What will influence your final decision regarding the mathematics subject you choose in Years 11 and 12?*", revealed Maths A students were more concerned about their own ability to do mathematics as they choose their subjects than they were about its relevance to everyday life. While it has been suggested that professional relevance is significant in subject choice decision-making (Brinkworth & Truran, 1998), for many students their perceived ability plays an important role. Just how these two influences relate to each other is unclear.

The preliminary findings of this research suggest that there is some positive correlation between relevance and mathematical ability, but whether the relevance of mathematics becomes more transparent as understanding (and achievement) in mathematics increases needs further investigation. This is needed to address the shortfall in students studying higher-level mathematics and entering STEM careers.

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