The Relevance of Mathematics: Leaders and Teachers as Gatekeeper for Queensland Senior Calculus Mathematics

Michael Easey
Australian Catholic University
<michael.easey@acu.edu.au>

Jim Gleeson
Australian Catholic University
<jim.gleeson@acu.edu.au>

The aim of the larger study, of which this paper is a part, is to investigate the decline in Year 10 male students' participation in senior calculus mathematics courses at an independent boys' school located in metropolitan Queensland. This paper draws on Sealey and Noyes's (2010) relevance framework to conduct document analysis and interviews with leaders and teachers concerning the relevance of mathematics. In both cases results indicated that there was a limited understanding of relevance of mathematics.

In 2012 the Office of the Chief Scientist (2012) indicated that within Australia there was a high demand for graduates to work in STEM related careers contributing to "a high technology, high productivity economy; to innovate and to compete at the high-end of provision" (p. 12). Attached to this demand was further concern that students' participation rates in senior calculus mathematics courses were declining (Office of the Chief Scientist [OCS], 2014) and as a result inspirational teaching and learning were needed to provide the gateway to increase students' uptake of senior calculus mathematics courses to meet such demands. However, inspirational teaching and learning are only two of many dimensions that have been identified as influencing student participation in senior calculus mathematics courses, with other research suggesting that gender (Vale & Bartholomew, 2008), school sector (Thomson, 2005), socioeconomic status (Ercikan, McCreith, & Lapointe, 2005), and geolocation (Kennedy, Lyons, & Quinn, 2014) also have implications. Important to note is that while no one dimension seems to be central, gender seems to be of particular concern. Differences in male and female student participation in mathematics have been a regular focus of Australian research (Kennedy et al., 2014; McPhan, Morony, Pegg, Cooksey, & Lynch, 2008) particularly in terms of senior calculus mathematics courses (Forgasz, 2006). Socioeconomic status is also featured in the literature (Thomson, De Bortoli, & Buckley, 2013) indicating that students with high socioeconomic status enjoy greater levels of achievement and proficiency in mathematics that favour participation in senior calculus mathematics courses compared to students with low socioeconomic background.

The above research suggests that high socioeconomic status male students, attending an independent school in a metropolitan context are better placed to participate in senior calculus mathematics courses. However, evidence involving one such school was found to be at odds with this literature. This problem has led to the research described in this paper that investigates this phenomenon further. This paper focuses on a dimension of this problem associated with the perceived relevance of mathematics. Relevance is a subjective term, the focus of which is determined by the perspectives of an individual or group (Ernest, 2004). There is limited knowledge concerning leaders' and teachers' perspectives of the relevance of mathematics, whether it is absent, singular, or nuanced. This investigation is critical for understanding why high socioeconomic status male students, attending an independent school in metropolitan context, do not select senior calculus mathematics courses. This paper will now consider current research before identifying the research question.

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Literature Review

The relationship between students' perspectives of the relevance of mathematics and their participation in senior calculus mathematics courses is reported in the literature using a range of terms, for example, "relevance" (Ainley, Kos, & Nicholas, 2008, p. 3), "utility" (Watt, Shapka, Morris, Durik, Keating, & Eccles, 2012, p. 305), and "usefulness" (McPhan et al., 2008, p. 7). According to McPhan et al. (2008), "usefulness" is a generic term used by students for a range of possibilities when considering studying senior mathematics courses. Participation in senior calculus mathematics courses has been further recognised as assisting in other subjects, meeting tertiary prerequisites, and providing and enhancing career opportunities (Brinkworth & Truran, 1998). This interpretation of relevance is important for this study and it links leaders' and teachers' perspectives of the relevance of mathematics. McPhan et al. (2008) provided some insights from a national survey that collected quantitative and qualitative data in which over half the teacher participants surveyed perceived that students' perception of the professional relevance of senior calculus mathematics courses was 'extremely influential' or 'very influential' towards students' participation in 'higher-level [calculus] mathematics' courses. Teachers in this study perceived that students' perspectives of the relevance of mathematics aligned with three themes: (1) careers; (2) learning and life; and, (3) internal university prerequisites. For example, teacher data from McPhan et al. (2008) concerning the future careers of students reflected, "Students need to have a clearer or better appreciation of why they need to do a topic and how it is linked to the real world situation" (p. 45). Regarding learning and life, "The reality is that nearly all other subjects hold a substantial real-world interest for students whereas mathematics keeps removing our students from it" (p. 45). In terms of internal university prerequisites, "Giving the higher maths greater recognition and reward for effort by, for example, being a requirement for more third level courses, and through more advantageous scaling of higher maths courses" (p. 45).

More recently Murray (2011) found that many students did not gain an understanding of the importance of mathematics at school and suggested that after leaving school they were often angry and disappointed about what they considered was a lost opportunity. More recently, Sealey and Noyes (2010) developed a theoretical framework to consider a more structured understanding of the relevance of mathematics, which can be used to describe why students choose to engage in post-compulsory and senior calculus mathematics courses. According to Sealey and Noyes (2010) relevance can be defined in an alternative way and developed a theoretical framework to support this perspective. They considered that the relevance of mathematics depended on an understanding of its practical, process, and professional relevance. For them, the practical relevance of mathematics relates to the immediate, real world use students ascribe to mathematics (e.g., conducting basic financial transactions or performing basic calculations). The value of students' understanding the everyday use of mathematics has been linked to increasing participation in post-compulsory mathematics courses (Hart & Walker, 1993) though it is not clear in research literature whether leaders and teachers are either aware or reinforce this notion. Process relevance represents a way of thinking, recognising that mathematics has widespread use, especially for problem solving in a range of disciples and contexts. Yet students do not seem to appreciate the transferability of mathematics with research (See for example New, Britton, Sharma, & Brew, 2012) indicating that students have limited ability to apply similar strategies to a variety of problems in different contexts. This suggests that leaders and teachers may not be astute regarding the fundamental role of mathematics across the curricula as underscored by the Australian Curriculum Assessment and Reporting Authority (Australian Curriculum Assessment and Reporting Authority [ACARA], 2016). The professional relevance of mathematics refers to the value of mathematics particularly for tertiary course and career pathways. The professional relevance students' associate with senior calculus mathematics courses has been found to be the strongest influence associated with student participation in senior calculus mathematics courses (Brinkworth & Truran, 1998). This was also the predominant understanding of the relevance of mathematics for leaders and teachers. This literature overview assisted in generating the research question guiding the development of this paper which was identified as: *How do [school] leaders' and teachers' in one metropolitan Queensland independent boys' perceive the practical, process, and professional relevance of mathematics?*

The Study

The results reported in this paper are part of a larger case study that focuses on the decline of Year 10 male students' participation in senior calculus mathematics courses. The study included document analysis and interviews with leaders and teachers at the research school to gather contextual information that informed the development of a survey to gather students' perspectives. The survey was then followed by student interviews to resolve unanswered questions that arose from student responses to open-ended questions in the survey. It is the document analysis and interviews with leaders and teachers at the research school that are reported in this paper.

Participants: Eight leaders and teachers from the research school were invited to participate in an interview at a school classified as high socioeconomic status according to My School, (ACARA, 2015). Their selection was based on gender, age, experience, and their role at this school. Consequently, four male and four female teachers were chosen. They were between 35 to 55 years of age and had 10 to 35 years of teaching experience.

Data Collection: Two types of data, documents and semi-structured teacher interviews, were used to consider whether students receive a balanced perspective of the practical, process, and professional relevance of mathematics. The documents analysed were the current Queensland Curriculum Assessment Authority (QCAA) syllabi for Mathematics B and Mathematics C, the two senior calculus mathematics courses offered in Queensland (Queensland Curriculum Assessment Authority [QCAA], 2014a, 2014b).

Leaders and teachers participated in semi-structured interviews where they were asked to share their perspectives of the decline in students' participation in secondary calculus mathematics courses at the school. The three leaders were in school curriculum or counselling roles and were interviewed individually due to their specific role and influence concerning school policy and student support. The remaining participants were mathematics teachers who all taught secondary mathematics classes. They were interviewed as a group due to their similar roles. The questions that guided the interviews were informed by the following themes developed from the literature review conducted for the larger study: School Context, Learning Mathematics, Mathematics Teaching, and the Relevance of Mathematics. Each interview lasted approximately 50 minutes, were audio recorded, and then transcribed.

Data Analysis: Analysis of documents and teacher interview data were conducted to explore the research problem through a manual coding process for the documents and through the use of a qualitative analysis software package, Leximancer. Document analysis is a systematic procedure for assessing document text to gain meaning, understanding, and knowledge. Document analysis requires finding, selecting, and evaluating data to yield themes (Labuschagne, 2003). Focusing on the rationales for each senior secondary mathematics course (QCAA, 2014a, 2014b) text data were examined and manually coded using grounded theory principles necessitating line-by-line analysis. Then, using an iterative process the researcher organised the coded text into themes.

Similarly, the teacher interview data were analysed using a grounded theory approach. However, analysing over 200 hundred pages of transcribed data manually was considered impractical. Consequently, Leximancer, a qualitative research software tool, was used to assist with the analysis. A word document of the transcribed teacher data was uploaded to Leximancer, which computed word frequencies and provided a visual analysis of trends and themes related to the data.

Results and Discussion

Results for both the document analysis and interviews are presented under the headings of practical, process, and professional relevance of mathematics (Sealey and Noyes, 2010). It is important to note at this point that there was no discernible difference between the male and female participants.

Practical Relevance

Document analysis of the QCAA Mathematics B and Mathematic C syllabus rationales revealed that no form of reference to practical relevance was mentioned. Similarly, leaders' and teachers' interview data also failed to include reference to practical relevance. This is of concern considering that in earlier research Hart and Walker (1993) identified that students with an understanding of the practical relevance of mathematics was related to their participation in post-compulsory mathematics courses. More recently McPhan et al. (2008) identified that students' understanding of the practical or real-world relevance of mathematics has important implications for their participation in higher-level mathematics courses.

Process Relevance

Similar to the results concerning the practical relevence of mathematics, the process relevance of mathematics was not represented in the QCAA senior Mathematics B or Mathematics C documents or leaders' and teachers' interviews data. These data are at odds with the mathematics rationale provided in the Australian Curriculum (ACARA, 2016) which stresses the critical importance of process relevance, stating, "The Australian Curriculum: Mathematics ensures that the links between the various components of mathematics, as well as the relationship between mathematics and other disciplines, are made clear" (p. 1). Queensland teachers will need to quickly address this issue if they are to fully embrace the Australian Curriculum as they have been working with the QCAA documents for many years.

Professional Relevance

In contrast to an absence of concern for the practical and process relevance of mathematics, the rationale for the Mathematics B (QCAA, 2014a) was highly focused on the professional relevance of mathematics. This syllabus states that the course is a, “precursor to tertiary studies in subjects with high demand in mathematics, especially in the areas of science, medicine, mining and engineering, information technology, mathematics, finance, and business and economics” (p. ii). This echoes rationale for the Mathematics C syllabus (QCAA, 2014b) that “provides additional preparation for tertiary studies in subjects with high demand in mathematics, especially in the areas of science, medicine, mining and engineering, information technology, mathematics, finance, and business and economics.” (p. ii). These rationales also provide an exhaustive list of future career pathways each underpins, for example:

> Mathematics B is designed for students whose future pathways may involve mathematics and statistics, and their application, in a range of disciplines at the tertiary level, including: mathematics and science education; natural and physical sciences, especially physics and chemistry; medical and health sciences, including human biology, biomedical, nanoscience and forensics; engineering sciences, including avionics, chemical, civil, communications, electrical, mechanical and mining; information technology and computer science, including electronic and software; mathematical applications in: energy and resource, management and conservation, climatology, design and built environment industry, manufacturing and trades, business and tourism, primary industries and environment, economics and commerce, statistics and data analysis, pure mathematics (QCAA, 2014a, p. 2)

The rationales for Mathematics B and Mathematics C focus strongly on the future career (professional) relevance of mathematics and promote STEM careers for which there is much demand (OCS, 2012, 2014). Important for this current research is that the limited understanding of the relevance of mathematics as provided by these syllabi has implications for teaching and learning in schools which was observed in the semi-structured interview with leaders and teachers.

Three themes emerged from the analysis of interview data that coalesced around the professional relevance of mathematics. These themes related to overall position (OP) ranking, post-school pathways, and employment opportunities. Students seeking to pursue tertiary studies after completing their senior secondary education must gain an OP ranking, which reflects a student’s overall senior achievement. The teachers argued that students tended to enrol in Mathematics B or Mathematics C, as they understood that enrolment in these subjects may improve their OP ranking and provide them with access to university courses all of which coincides with the research of Brinkworth and Truran (1998) that examined the influences on students' reasons for studying or not studying mathematics. Typical of leaders’ and teachers’ perceptions concerning students’ perspectives were, “Maths B will be good for my OP” and “… doing Maths B is better than Maths A for your OP”. These positions represent a narrow perspective consistent with the syllabi rationales. It can only be assumed that these strongly held perspectives are expressed to Year 10 students when they are choosing their senior mathematics courses leading to their post-school pathways. This approach can be considered a long-term investment strategy for students rather than being in the moment and focusing on the immediate relevance of mathematics leading to broader opportunities.

The teachers were passionate about supporting students who show a clear aptitude towards mathematics. Typical of the comments made by teachers was, “students who are capable are encouraged to participate in Theta mathematics where our best teachers can work with them to achieve their goals”. This approach had immediate benefits for the teachers as they had dedicated and interested students in their classes, as one teacher commented, “Because they’re smart they’re interested, they’re often easier to teach compared to students who struggle". At the same time a leader commented that, "the wide range of abilities makes it hard for teachers to deal with the needs of all students, especially those that struggle."

Rather than providing inspirational teaching and learning to these students to increase the uptake of senior calculus mathematics courses as suggested by the Office of the Chief Scientist (OCS, 2014) students who do not demonstrate an obvious aptitude for mathematics are actively discouraged from selecting or participating in senior calculus mathematics courses. One typical comment concerning this practice being, "In Year 10, we actually weed out the weak. We specifically and actively take them out of Maths Prep B because they're failing. They can't handle it." This approach means there are no support mechanisms for students who want to go on to study Mathematics B or Mathematics C lacking obvious aptitude for mathematics. As suggested by a leader, "We have a large group of students caught in the middle academically and it's not possible to lift their standards to the level required for Maths B and C".

Paradoxically, during the interviews the leaders and teachers tended to place the "blame of failure on those most at risk" (Zevenbergen, 2003, p. 135) by being critical of current Years 11 and 12 students who were preparing to make their tertiary study choices. They argued that "they had not selected the correct senior mathematics course when in Year 10 and were not prepared for the tertiary course they intended to pursue". It seems that the students and their potential future aspirations were not placed at the centre of the decision making process and as a result were disadvantaged by the practice of "weed[ing] out the weak" as described by one teacher. Another example of this perspective evident among leaders and teachers was, "some boys were choosing Maths A because Maths B is not a prerequisite for them [to enter a university based course of study]. But they do go on into business fields, and they're lacking the [mathematics] background". Here a lack of useful course guidance for students is considered their problem or oversight.

The leaders took a different view of this matter, demonstrating some empathy for the students who were deselected. For example, the school counsellor was committed to setting up outcomes that result in long-term employment and financial security as well as work place satisfaction for students who were unlikely to gain access to university. Unfortunately, this means that as much as a quarter of students who could become part of the STEM community with additional support from inspiring teachers and teaching, but who are not given this opportunity by the leaders and teachers in this school due to deselection. The school counsellor also discussed the importance of mathematics to improve employment opportunities and made the important connection between studying senior calculus mathematics courses and going straight from school to commence an apprenticeship:

> If they [boys at the school] want to get a job straight after Year 12 with Ergon Energy or Energex [large energy providers in Australia] or any of those big companies, the kid with Maths B going for a trade will be taken in preference because the electrical trades do probably have a greater demand on maths than most of the other trades.

Teachers at the school perceived that their students viewed mathematics only in terms of professional relevance. One teacher commented "Well the kids ask themselves the question, do I need this for my job? – If no, then I won't do it."

Implications and Conclusions

This study has identified four important findings worthy of consideration. First, it is evident that the senior Mathematics B and Mathematics C syllabuses in Queensland and both leaders and teachers at this school lacked a nuanced understanding of the three types of relevance of mathematics as described by Sealey and Noyes (2010) being practical, process and professional relevance. They did not reflect practical or process relevance both did strongly promoted the professional relevance of mathematics. Unsurprisingly, the leaders and teachers reported that the students' perspectives of the relevance of mathematics were also focused on the professional relevance of mathematics with leaders and teachers perceiving that students were only interested in studying senior calculus mathematics to increase their OP.

Second, during the Year 10 subject selection process, students who were not considered mathematically capable by leaders or teachers, are directed to study less demanding mathematics courses such as Mathematics A. Here they were quick to remove the potential by encouraging these students in enrol in Mathematics A. Therefore, it appears that students in this high socioeconomic school are being deselected at a critical point in their education when they are at an early age.

Third, there is no doubt that the deselection approach adopted by the school seems to focus on the short-term benefit for the teachers. The ultimate outcome is that only those high achieving students continue to be supported to further advance their opportunities. It seems that the teachers in this high socioeconomic status, independent, male, metropolitan school act as "gatekeepers" (Spielhagen, 2011, p. 51) to future career success rather than facilitating opportunities for all students in their classroom to succeed.

Fourth, students' opportunity to study senior calculus mathematics courses is restricted when they do not have fully developed future aspirations, which ultimately limits their future potential. Most interestingly, less than inspirational teaching and learning practices at the school supported leaders and teachers bringing about an outcome where their advice to students and their family is that they should enrol in Mathematics A rather than Mathematics B or Mathematics C.

This study provides a more sophisticated understanding of the problems associated with students' senior calculus mathematics course selection. While the issues identified appeared to be underpinned by mathematics course syllabuses, it highlights the pivotal role of leaders and teachers in schools as gatekeepers, encouraging or discouraging students' senior calculus mathematics course selection. It a recommendation of this study that further investment is required to inspire leaders and teachers to cultivate a full understanding of the relevance of mathematics as well as student-centred guidance skills that encourages student participation in senior calculus mathematics courses.

References

Ainley, J., Kos, J., & Nicholas, M. (2008). *Participation in science, mathematics, and technology in Australian education.* Camberwell: Australian Council of Educational Research.

Australian Curriculum Assessment and Reporting Authority. (2016). Learning area: Mathematics rationale. Retrieved 17 January 2016 from the World Wide Web: http://www.australiancurriculum.edu.au/Mathematics/Rationale.

Australian Curriculum Assessment and Reporting Authority. (2015). My school. Retrieved 1 September 2015 from the World Wide Web: http://www.myschool.edu.au/Main.aspx?PageId=0&SDRSchoolID=QLDC0000005366&DEEWRID=15652&CalendarYear=2009.

Brinkworth, P., & Truran, J. (1998). *A study of the influences on students' reasons for studying or not studying mathematics.* Adelaide: Flinders University.

Ercikan, K., McCreith, T., & Lapointe, V. (2005). Factors associated with mathematics achievement and participation in advanced mathematics courses: An examination of gender differences from an international perspective. *School Science and Mathematics, 105*(1), 5-14.

Ernest, P. (2004). Utility versus relevance: Some ideas on what it means to know mathematics. In B. Clarke (Ed.), *International perspectives on learning and teaching mathematics*. Göteborg: Göteborg University and The National Center for Mathematics Education.

Forgasz, H. (2006). *Australian Year 12 mathematics enrolments: Patterns and trends - past and present.* Melbourne: Australian Mathematical Science Institute and International Centre of Excellence for Education in Mathematics.

Hart, L., & Walker, J. (1993). The role of effect in teaching and learning mathematics. In D. Owens (Ed.), *Research ideas for the classroom: Middle grades mathematics*. New York: Macmillan.

Kennedy, J. P., Lyons, T., & Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science, 60*(2), 34-46.

McPhan, G., Morony, W., Pegg, J., Cooksey, R., & Lynch, T. (2008). *Maths? Why not?* Canberra: Department of Education, Employment and Workplace Relations.

Murray, S. (2011). Declining participation in post-compulsory secondary school mathematics: Students' views of and solutions to the problem. *Research in Mathematics Education, 13*(3), 269-285.

New, P., Britton, S., Sharma, M., & Brew, A. (2012). *Researching the transferability of mathematical skill.* Paper presented at the Proceedings of the Research and Development into University Science Teaching and Learning Workshop, Sydney, University of Sydney.

Office of the Chief Scientist [OCS]. (2012). *Mathematics, engineering, and science in the national interest*. Canberra, ACT: Commonwealth of Australia.

OCS. (2014). *Science, technology, engineering, and mathematics: Australia's future.* Canberra, ACT: Commonwealth of Australia.

Queensland Curriculum and Assessment Authority [QCAA]. (2014a). *Mathematics B senior syllabus*. Retrieved 17 January 2016 from the World Wide Web: http://www.qsa.qld.edu.au/downloads/senior/snr_maths_b_08_syll.pdf.

QCAA. (2014b). *Mathematics C senior syllabus*. Retrieved 17 January 2016 from the World Wide Web: http://www.qsa.qld.edu.au/downloads/senior/snr_maths_c_08_syll.pdf.

Sealey, P., & Noyes, A. (2010). On the relevance of the mathematics curriculum to young people. *The Curriculum Journal, 21*(3), 239-253.

Spielhagen, F. R. (2011). *The algebra solution to mathematics reform: Completing the equation*. New York: Teachers College Press.

Thomson, S. (2005). Pathways from school to further education or work: Examining the consequences of Year 12 course choices. Retrieved 20 September 2015 from the World Wide Web: http://research.acer.edu.au/lsay_research/46.

Thomson, S., De Bortoli, L., & Buckley, S. (2013). *PISA 2012: How Australia measures up.* Camberwell, Victoria: Australian Council for Educational Research.

Vale, C., & Bartholomew, H. (2008). Gender and mathematics: Theoretical frameworks and findings. In H. Forgasz, A. Barkatsas, A. Bishop, B. Clarke, S. Keast, T. Wee, & P. Sullivan (Eds.), *Research in mathematics education in Australasia 2004-2007* (pp. 271-290). Rotterdam: Sense Publishers.

Watt, H., Shapka, J., Morris, Z., Durik, A., Keating, D., & Eccles, J. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. Retrieved 20 June 2013 from the World Wide Web: http://www.ncbi.nlm.nih.gov/pubmed/22468566.

Zevenbergen, R. (2003). Teachers' beliefs about teaching mathematics to students from socially disadvantaged backgrounds: Implications for social justice. In L. Burton (Ed.), *Which way social justice in mathematics education?* (pp. 133-151). Westport, CT: ABC-CLIO.