

Teachers' Perspectives Regarding the Decline in Boys' Participation in Post-Compulsory Rigorous Mathematics Subjects

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

This paper explores the decline in boys' participation in post-compulsory rigorous mathematics using the perspectives of eight experienced teachers at an independent, boys' College located in Brisbane, Queensland. This study coincides with concerns regarding the decline in suitably qualified tertiary graduates with requisite mathematical skills and abilities to meet increasing employment demands and opportunities in science, technology, engineering, and mathematics (STEM) careers. Individual interviews and a focus-group interview with teachers in various curriculum leadership, careers/counselling, and mathematics teaching roles revealed...

The decline in students' participation in post-compulsory rigorous¹ mathematics subjects (referred to rigorous mathematics hereafter) represents an international trend in many progressive economies. Recent research regarding student participation in rigorous mathematics in The United Kingdom (UK) (Noyes & Sealey, 2009, 2012) identified that there had been a "gradual decline" since the 1980's. Similarly, in Australia student participation in rigorous mathematics has also been identified as declining, especially compared to the increase in students studying less rigorous² mathematics subjects (McPhan, Morony, Pegg, Cooksey, & Lynch, 2008; Thomas, 2000). This decline has important implications including the reduced number of graduates available to teach secondary mathematics in schools and the reduced pool of tertiary graduates able to meet increasing demands in science, technology, engineering, and mathematics (STEM) careers.

This paper presents teachers' perspectives of factors that influence boys' choice to participate in rigorous senior mathematics subjects. Teachers' perspectives reported in this paper are part of a larger study that focuses on exploring an observed decline in boys' participation in rigorous mathematics subjects at an independent boys' school, Omega College (pseudonym), in Brisbane, Queensland. In Queensland rigorous senior mathematics includes Mathematics B and Mathematics C. While Mathematics B prepares students for undertaking tertiary studies requiring a high-level of mathematics, Mathematics C provides students with additional preparation to pursue "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" (Queensland Studies Authority, 2008, p. i). Students studying Mathematics C also study Mathematics B concurrently.

The literature has identified that students' choice to participate in rigorous mathematics subjects is influenced by four main dimensions: (a) school context, (b) learning mathematics, (c) mathematics teaching, and (d) the relevance of mathematics.

A school environment conducive to learning is important for students to have high achievement. In particular the boys' experience in the school context will influence their

¹ Rigorous describes post-compulsory mathematics courses where, for example, advanced algebra, functions, applied statistics, calculus, real and complex numbers, matrices, and vectors is studied.

² Less rigorous post-compulsory mathematics courses where, for example, statistics, probability, measurement, applied geometry, and managing money is studied.

engagement in academic subjects in general and mathematics specifically. Data from countries³ that participated in the Trends in International Mathematics and Science Study (TIMSS) Advanced 2008 revealed that rigorous mathematics learning and achievement amongst secondary school students was associated with several contextual factors in a school. Factors included the Principal, the availability of mathematics teachers, the school climate, and the level of school safety (Garden et al., 2006). In terms of school climate, students who have enjoyed a sense of belonging, acceptance, and respect at school experienced increased levels of academic achievement (Khoo & Ainley, 2005; Ma, 2003; Sergiovanni, 2000). However, it has also been suggested that boys find schools difficult, unfriendly environments (Hawkes, 2001) where they not only struggle with self-esteem, but also their ability to engage, learn, and achieve academically (Legewie & DiPrete, 2012). In the context of boys' schools, the interplay between alternate types of masculinities amongst boys, for example, those focused on sport, study, culture, or music has been identified as influencing the climate of the school and boys' participation and regard for education (Connell, 2000; White, 2004). Boys' experience of the school context will influence their participation and achievement in mathematics.

A positive disposition positive towards learning mathematics amongst students positively influences their participation in rigorous mathematics subjects (Ma, 2006). As students develop, their disposition towards learning mathematics focuses on what they perceive mathematics is and how competent they feel when doing mathematics. Students' disposition towards learning mathematics is shaped by their classroom experiences which informs both their beliefs (perceived truths) and attitudes (feelings) about learning mathematics (McLeod, 1992). Students' beliefs about learning mathematics are also known to influence their attitudes (Ajzen, 1989). For example, a belief that mathematics is a difficult subject to study can coincide with negative attitudes towards learning mathematics. Conversely, a student who believes learning mathematics is gratifying is more likely to hold positive attitude towards learning mathematics. Supporting this perspective, data from a survey of 16-year-old students ($N=1500$) studying post-compulsory mathematics subjects in the UK held negative beliefs regarding mathematics, describing it as a difficult, irrelevant subject, which they disliked studying. This is supported by research findings where students felt that mathematics was boring and unenjoyable (Brown, Brown, & Bibby, 2008). Thus students' beliefs and attitudes regarding mathematics will influence their engagement in the subject.

Certain types of teacher knowledge have also been identified as influencing students' engagement, learning and achievement. Shulman (1986) identified that teachers' knowledge of (a) learners, (b) curriculum (c) subject content, and (d) pedagogical content were related to student learning and achievement. Knowledge of learners referred to teachers' understanding of individual student's cognitive, social, and emotional needs in the classroom context. Curriculum knowledge focused on the teachers' grasp of the materials and resources that facilitated positive, creative, learning experiences that engage students. Both teachers subject content knowledge and teacher pedagogical knowledge were identified as important in combination. While subject content knowledge demanded a deep understanding of the teaching domain, it also informed a teachers' unique, practical knowledge to teach a subject (pedagogical knowledge). Teachers' content and pedagogical knowledge will impact student engagement in rigorous mathematics.

³ Armenia, Iran, Italy, Lebanon, Netherlands, Norway, Philippines, Russian Federation, Slovenia, and Sweden.

In recent years the importance students' associate towards the usefulness of mathematics has emerged as an additional element known to influence their participation in post compulsory mathematics subjects. The results of two Australian studies (Brinkworth & Truran, 1998; McPhan, et al., 2008) state that students' subject choice was influenced by their perceived usefulness of studying rigorous mathematics subjects. Perceived usefulness included the enhanced tertiary opportunities it offered. More recent research (Sealey & Noyes, 2010) with Year 11 secondary students in UK schools ($N=16$) revealed that the utility, or relevance, students associated with mathematics was not homogenous and varied in the three ways according to their social contexts, namely, practical relevance (solving simple day-to-day problems), process relevance (conceptualising and solving problems in other contexts), and professional relevance (enabling tertiary choices and career pathways). Research illustrates that students need to see the usefulness and relevance of rigorous mathematics in order to pursue it.

Many of these previous studies have focussed on students' perspectives regarding the decline in mathematics. Few studies have explored the problem from teachers' perspective. Thus the particular questions that guided this dimension of the research were: What are teachers' perspectives regarding the decline in boys studying high level of mathematics? and, How do teachers' believe that this problem can be addressed?

Methodology

Interviews were conducted with eight purposively selected teachers. Two experienced teachers in executive Learning and Teaching roles and an experienced student-careers counsellor participated in individual interviews. A group of five experienced mathematics teachers who taught secondary and senior secondary classes were interviewed together. While participants represented a mixture of ages, roles and responsibilities at Omega College there was a balance between the number of male and female teachers interviewed.

Four dimensions identified from the literature informed the interview instrument:

1. How does school culture influence boys' choice to study rigorous mathematics subjects?
2. How do boys' perspectives of mathematics teachers' beliefs and attitudes regarding mathematics and mathematics teaching influence their choice to study rigorous mathematics subjects?
3. How do boys' perspectives of how mathematics is taught influence their choice study rigorous mathematics subjects?
4. How do boys' personal beliefs about mathematics and mathematical learning influence their choice to study rigorous mathematics subjects?

The instrument consisted of 14 semi-structured questions, a selection of which were:

1. Do students consider studying mathematics is important?
2. What do students perceive about studying rigorous mathematics subjects?
3. What has contributed to the decline in boys' participation in rigorous mathematics subjects at the College?
4. Is student participation in rigorous mathematics subjects promoted at the College?

The individual interviews and focus group interview required approximately 45 minutes to complete. Each of the four interviews were audio recorded and transcribed to facilitate the analysis of data. The data were coded, analysed and organised into relevant themes and subthemes using Atlas.ti (Version 6.2), a Computer Assisted Qualitative Data

Analysis Software (CAQDAS) program, designed to facilitate the management and analysis of qualitative data.

Results

The analysis of the teacher interview data was consistent with four dimensions: (a) school culture, (b) learning mathematics, (c) mathematics teaching, and (d) the relevance of mathematics. Tables 1, 2, 3, and 4 present each theme, and some associated subthemes of teachers' perspectives.

Table 1

Teachers' Perspectives of how School Culture Influenced the Decline in Boys' Participation in Rigorous Mathematics Subjects at Omega College

Theme	Subtheme	Teachers' perspective
School culture	Academics	Mismatch between academic expectations and standard
	Sport	Omega College widely perceived as a sporting institution
	Student culture	Non-academic boys remaining at school perceived as problematic

Elements of academics, sport, and student culture within the school culture at Omega College were seen as influencing the decline in boys' participation in rigorous mathematics subjects. Teachers' perceived that the focus at Omega College was aligned with sport rather than the high academic expectations espoused. Parents and students selected to attend the College because of the sporting opportunities it provided rather than for academic purposes. Increasingly, students were completing Years 11 and 12 who were not academically motivated which posed problems for their own performance and classroom culture. Teachers perceived that elements of the current College culture resulted in fewer boys pursuing rigorous mathematics.

Table 2

Teachers' Perspectives of how Learning Mathematics has Influenced the Decline in Boys' Participation in Rigorous Mathematics Subjects at Omega College

Theme	Subthemes	Teachers' perspective
Learning Mathematics	Values	Boys did not consider mathematics an important body of knowledge
	Beliefs	Boys perceived participation in rigorous mathematics subjects required special mathematical ability
	Attitudes	Boys perceived rigorous mathematics subjects was not enjoyable

Teachers identified that the values, beliefs, and attitudes boys held towards learning mathematics influenced the decline in participation in rigorous mathematics at Omega College. Teachers perceived that boys did not value or regard mathematics as an important subject. Teachers perceived that boys believed participation in rigorous mathematics subjects required special mathematical ability that they did not possess and that boys were not prepared to commit to the workload required. Additionally, teachers identified that boys held negative attitudes towards learning mathematics, indicating that mathematics was a difficult and disinteresting subject to study. Boys at the College avoided participation in rigorous mathematics subjects because they: (a) perceived they did not

have the requisite ability; (b) held beliefs that mathematics was difficult and boring; and, (c) feared attempting a subject in which they could fail.

Table 3

Teachers' Perspectives of how Mathematics Teaching has Influenced the Decline in Boys' Participation in Rigorous Mathematics Subjects at Omega College

Theme	Subthemes	Teachers' perspectives
Mathematics teaching	Mathematics teachers' subject knowledge	Teachers needed mathematics training to teach effectively
	Mathematics teachers' pedagogical knowledge	Pedagogical approach that provides practical, useful learning tasks
	Mathematics teachers' ability to communicate	Communication vital component of teaching
	External issues impacting on teaching	Decline in available, qualified mathematics teachers at Omega College
	Mathematics teachers' relational ability	Teacher-student relationship strongly contributed to engagement, learning, and achievement

Teachers perceived that certain aspects of teacher subject and pedagogical knowledge were important factors in students' engagement in rigorous mathematics. Teachers indicated that mathematics teaching required specialised training to develop the requisite knowledge, understanding, and skills needed to effectively teach students across secondary and mathematics subjects, especially rigorous levels. The ability of mathematics teachers to communicate effectively, clearly and simply, to students was identified as a critical element of teaching mathematics as was the need for good relations between mathematics teachers and their students. Teachers indicated that positive teacher-student relationships enhanced students' secondary engagement, learning, and achievement. There was conjecture regarding the influence of teacher-student relationships on boys' post-compulsory mathematics subject choice with some saying that the students do not consider these factors in the decision-making. While some teachers understood the importance of their knowledge and pedagogy on students' engagement in mathematics, others downplayed their impact on student subject selection.

Theme 4

Teachers' Perspectives of how the Relevance of Mathematics has Influenced the Decline in Boys' Participation in Rigorous Mathematics Subjects at Omega College

Theme	Subtheme	Teachers' perspective
Relevance of mathematics	Relevance of mathematics for tertiary or career pathways	Rigorous mathematics not required for tertiary or career pathways
	Impact on overall position results	Boys study rigorous mathematics to improve their overall position result
	Improving employment prospects	Boys chose rigorous mathematics to improve their employment prospects

The relationship between the relevance of mathematics and boys' participation in rigorous mathematics subjects at Omega College was seen as centring on professional

relevance, and directly influenced their engagement in rigorous mathematics. Teachers perceived that boys' choice to participate in rigorous mathematics subjects was conditional, according to whether rigorous mathematics was required for student's tertiary course or career requirements, improved their overall position (OP) result or immediate employment prospects. Teachers concluded that boys' choice to study rigorous mathematics was mostly dependant on whether it was relevant for their professional goals.

Discussion

The findings from the teacher interviews indicated that their perspectives supported and conflicted with four dimensions identified in the literature as influencing students' participation in rigorous mathematics: school culture, learning mathematics, mathematics teaching, and, the relevance of mathematics. First, with regard to school culture, the literature predominantly saw the main aspects that influenced boys' participation in the school culture as an affective/socio-cultural issue. Boys find it difficult to operate in an unfriendly environment (Hawkes, 2001), require a sense of belonging (Khoo & Ainley, 2005), and experience levels of safety (Garden, et al., 2006), positive aspects that are perceived to assist them engage in learning. These are also dimensions that teachers themselves can have some influence over. The teachers in this study did not identify any of these dimensions in the interviews. In contrast, they saw the school culture as fairly negative and something beyond their control. For them, issues included the mismatch between academic expectations and lived reality, that is, the predominance of sport and a culture consisting of disengaged boys who were forced to remain at school as a result of recent Government legislations. While some teachers indicated that the College Executive were aware of the need to establish a balance between academic and sporting pursuits, other teachers perceived this need was contentious. In fact many stated that the sporting culture was what the College was about. No strategies were identified to address the specific issues in short or long term, through planning or initiatives. Thus, the problems teachers perceived with regards to the school culture continue to exist and perpetuate the decline in boys' engagement in rigorous mathematics.

A survey of the literature concerning the second dimension, learning mathematics, revealed that a student's disposition towards mathematics was a critical element in their engagement. As suggested earlier, positive disposition towards learning mathematics has been identified as positively influencing students participation in rigorous mathematics subjects (Ma, 2006). A student's disposition towards mathematics is underpinned by the beliefs and attitudes they develop learning mathematics (McLeod, 1992). Mathematics teachers at Omega College have a unique role, responsibility and opportunity to positively shape students' beliefs and attitudes towards mathematics so that it is perceived as achievable and enjoyable (Ajzen, 1989). However, the data revealed that boys at the College did not have a positive disposition towards learning mathematics. Teachers identified that boys did not believe that they had the requisite ability required to participate in rigorous mathematics, and felt boys perceived learning mathematics was difficult. Most concerning was the teacher perspective that students did not value learning mathematics as it was "not an important body of knowledge". While similar negative beliefs and attitudes have been previously reported in the literature (Brown, et al., 2008) concerns must still exist for teachers regarding the beliefs and attitudes students have toward learning mathematics at Omega College as it is the teachers who provide the experiences associated with learning mathematics that inform students values, beliefs, and attitudes.

Effective student learning and achievement, according to Shulman (1986), is predicated by teachers' knowledge of (a) learners, (b) curriculum, (c) subject content, and (d) pedagogical content. The third dimension, which considered the influence of mathematics teaching on the research problem, identified that teachers perceived two of the four types of knowledge were critical - subject content knowledge, a profound understanding of the teaching domain, and pedagogical content knowledge, the practical knowledge required to teach a subject. In contrast, the cognitive, social, and emotional needs of learners (knowledge of learners) and use of materials and resources that facilitated positive, creative, learning experiences in the classroom (knowledge of curriculum) received little focus. Thus, the data revealed a preoccupation with teacher-focused skills and ability to teach mathematics rather than any direct consideration for the needs of the learners. This functional approach was further supported by data that indicated teachers perceived their communication skills and relational abilities were critical to facilitate learning and achievement. While these teachers-focused skills and abilities are important, a more student centred approach may have important implications for redressing the decline in boys' participation in rigorous mathematics.

The usefulness or relevance of mathematics has recently been identified as influencing students' participation in mathematics and is considered in the fourth dimension of this paper. Research in Australia (Brinkworth & Truran, 1998; McPhan, et al., 2008) revealed that students' choice to study post-compulsory mathematics and rigorous mathematics was influenced by students' perception of the usefulness of mathematics for their tertiary or career trajectory. Similarly, the data indicated that teachers' perceived boys at Omega College only participated in rigorous mathematics when they perceived it was relevant for their tertiary courses or career pathways. The nuanced understanding of relevance provided by Sealey and Noyes' (2010) indicates that there is a range of practical, process, and professional relevance associated with studying mathematics. However, it is unclear whether teachers or boys were aware of these nuances and if they influenced choice.

Conclusion

Teachers' insights into why there is a low participation rate in high levels of mathematics at Omega College, on the whole were centred around the boys themselves. In addition, teachers saw that many of the impediments to boys' participation were beyond their control. For example, many boys were seen as either incapable of engaging in higher levels of mathematics, or were at the College to participate primarily in sport. Even though they perceived that many boys thought mathematics was an unimportant difficult subject, there was no mention of how they could redress this nor did there seem to be any wish for them to do so. They also seemed to feel that the problem was unrelated to their teaching, although they did concede that the relationships they had with boys were important to boys' participation. There seemed a great deal of complacency on the part of these teachers. The reasons for this were difficult to discern. Was it because of the perceived traditions of the Omega College itself? Or was it simply because they were overwhelmed by the changing demographics of the boys attending? Finally, if these were the perspectives of these teachers, how did they boys respond to this? What are their reasons for choosing or not choosing to study high levels of mathematics?

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