Increasing Participation of Students from Disadvantaged Backgrounds in Challenging Mathematics Subjects

Anne Bennison
University of the Sunshine Coast
abenniso@usc.edu.au

Calls for high levels of participation and success in Science, Technology, Engineering and Mathematics (STEM) by all Australians exacerbates the need for research into improving participation in mathematics by students from disadvantaged backgrounds. Rogoff's three planes of analysis is used to foreground the institutional plane in a low socioeconomic status school with sustained increased enrolments in Mathematics B (now replaced by Mathematics Methods). Processes in this plane are examined by drawing on semi-structured interviews with a Deputy Principal and Head of Mathematics. Contributing factors appear to be the way that the Mathematics Program and Pastoral Care Program are delivered at the school.

Science, Technology, Engineering and Mathematics (STEM) disciplines are crucial in a rapidly changing world in which advances in technology effect almost every aspect of daily life (Department of Education, 2022). A long-term strategic view of STEM to ensure Australia's economic prosperity was outlined almost 10 years ago (Office of the Chief Scientist, 2014). Australia's competitiveness (characterised by innovation, links between industry and research, and a flexible workforce), education and training, research, and international engagement were seen as crucial for building a competitive economy. One of the education and training goals was for "high levels of participation and success in STEM for all Australians, including women, Indigenous students, and students from disadvantaged and marginalised backgrounds" (p. 20). A barrier to participation and success in STEM for students from disadvantaged backgrounds is that they are over-represented among those who do not meet national and international benchmarks in mathematics (e.g., Thomson et al., 2020). Consequently, students from such backgrounds are less likely than their peers from more privileged backgrounds to study challenging mathematics subjects, such as Mathematical Methods (a subject taken in the final two years of school that includes the study of calculus, probability, and statistics), that underpin STEM disciplines. Murphy (2018), for example, found that the proportion of students enrolled in Mathematics Methods in Year 12 in Victoria averaged across 2014 to 2016 was 0.064 in the highest socioeconomic status (SES) schools compared to 0.039 in the lowest SES schools. Mathematical Methods is not only required for STEM disciplines but also provides the necessary foundation for an extremely broad range of professions including economics and the social sciences. In a recent review of Australasian research on equitable, socially just, and ethical mathematics education, Vale et al. (2020) called for more research on how to improve participation and achievement in mathematics in schools in low SES communities. This study seeks to contribute to addressing this gap in literature.

The aim of this study was to identify and understand factors that contribute to promoting sustained engagement with mathematics in early secondary years (Year 7, Year 8, and Year 9) among students from disadvantaged backgrounds. The study extends earlier research (Bennison et al., 2018), which focussed on students in the later years (Year 10 and Year 11), by shifting the focus to younger students who are yet to make critical subject choices for the senior phase of schooling. The earlier research identified some schools located in low SES areas in Queensland that have achieved sustained increased enrolments in Mathematics B (replaced by Mathematics Methods in 2019). The present study explores factors that may influence students' mathematical aspirations and engagement in the early years of secondary schooling in one of these schools. The goal is to identify factors that may motivate students in this school to choose to study Mathematics B in their final two years of school. Using Rogoff's (1995) three planes of analysis, overlapping personal, social, and institutional factors were explored to identify and understand possible reasons for students' sustained

(2023). In B. Reid-O'Connor, E. Prieto-Rodriguez, K. Holmes, & A. Hughes (Eds.), *Weaving mathematics education research from all perspectives*. *Proceedings of the 45th annual conference of the Mathematics Education Research Group of Australasia* (pp. 99–106). Newcastle: MERGA.

engagement in mathematics in this school. The focus of this paper is at the institutional level. The following research question is addressed:

- What institutional factors appear to be effective in promoting sustained engagement with mathematics at Cassowary Secondary College?

Theoretical Framework

There are many competing and interwoven factors that influence students' selection of mathematics subjects for their final two years of schooling. For this reason, a sociocultural approach that takes into consideration interconnected personal, social, and institutional factors is warranted. Rogoff's (1995) three planes of analysis provides a way of examining the *person-in-context* that allows the focus of analysis to foreground the individual, their interactions with others, or institutional processes while keeping in mind that activities in each of these planes take place in the context of the other planes. Rogoff regards these planes of focus "not as separate or as hierarchical, but as simply involving different grains of focus with the whole sociocultural activity. To understand each requires the involvement of the others" (p. 141). Thus, any analysis using this theoretical framework must begin by developing an understanding of each of the planes. Developing students' aspirations to study more challenging mathematics subjects in their final two years of schooling was seen as the sociocultural activity of interest in this study. The personal plane *zooms in* on the individual and encompasses factors such as a student's beliefs about mathematics and their future career plans. The social plane *zooms out* to view how interactions the individual has with peers, teachers, and parents shape their aspirations. *Zooming out* further brings the institutional plane into focus. This plane allows attention to be placed on practices within the school that provide the context in which personal and interpersonal processes take place. This plane is foregrounded in this paper.

Rogoff (1995) used the metaphors of *apprenticeship*, *guided participation*, and *participatory appropriation* to explain developmental processes taking place in the institutional, social, and personal planes, respectively. She used the metaphor of apprenticeship for the institutional plane to illustrate how attention in this plane is on the role of the individual and others as well as the "cultural/institutional practices and goals of the activities to which they contribute" (p. 143). Individual development in this plane takes place through participation in activities with others in a community of practice (Wenger, 1998). Thus, the institutional plane is foregrounded while recognising the contribution of processes taking place in the personal and social planes. In this study, the institutional plane encompasses how the school arranges activities (i.e., how mathematics is offered) and supports students in the junior secondary years that may contribute to sustained engagement in mathematics. The outcome of this sustained engagement is students choosing to study Mathematics B in their final two years of schooling.

Research Design

This project was conducted in 2019 and is developing a case study (Stake, 2003) of a school located in a low socioeconomic status (SES) area in Queensland where there was a sustained increase in enrolment in Mathematics B (the predecessor of Mathematics Methods in Queensland) over 2013-2017 (the most recent 5-year period for which relevant data was available when the project was conducted). Ethics approval (A191208) was granted by the university involved in the project, and participants and parents/caregivers gave informed consent. Permission to conduct the research at the school was given by the jurisdictional authority and the principal. The name of the school and names of participants are pseudonyms.

School Selection and Context

The project employed purposeful sampling using publicly available Queensland Curriculum and Assessment Authority (QCAA) enrolment data to determine possible sites. A sustained increase in

enrolment in a subject was considered to have occurred if the ratio of enrolment in Mathematics B in 2017 in Year 12 to that in 2013 was greater than one and the ratio of the school population in 2017 to that in 2013 was close to one (i.e., the school population was stable). A further constraint was that subject enrolment for both years was greater than 10. For schools which met these criteria, schools with an Index of Community Socio-Educational Advantage (ICSEA) (ACARA, 2015) of less than 1000 were identified. Final school selection was determined by convenience sampling based on school location and willingness of the principal to participate in the study. Cassowary State Secondary College met the criteria and was chosen for the study.

Participants

Cassowary State Secondary College's senior administration consisted of a principal supported by three deputy principals, including *Chris* who was responsible for mathematics, science, and numeracy. The Mathematics Department was led by *Elizabeth*, and included *Karen*, who taught a Year 7 Extension class; *Susan* and *Janelle*, who each taught a Year 8 Extension class; *Melissa*, who taught a Year 9 Extension class; and *Will* and *Paul* who were responsible for numeracy in the first and second half of 2019, respectively. All named school staff participated in the study. Twenty-one students from the extension classes (seven from Year 7, nine from Year 8 and five from Year 9) also participated in the study though focus group interviews. Data collection took place during school visits in June and November. As attention in this paper is on factors at the institutional level, data drawn on is the interviews with Chris and Elizabeth.

Data Collection

Chris and Elizabeth were interviewed in June and a follow-up interview was conducted with Elizabeth in November. Semi-structured interviews were used to determine what institutional factors might have an impact on students' aspirations to study Mathematics B in their final two years of schooling. Questions sought information on the participant's background, how mathematics was delivered at the school, and why participants thought there had been an increase in enrolments in Mathematics B in the nominated 5-year period. Interviews lasted between 34 and 43 minutes, were audio recorded, and transcribed.

Data Analysis

An inductive content analysis (Silverman, 2013) of interview transcripts was employed to identify factors at the institutional level that may contribute to engagement in mathematics at the Cassowary Secondary College. All transcripts were initially read to identify potential themes. These tentative themes were used to code the transcript of the interview with Chris (Deputy Principal), then applied to the two interviews with Elizabeth (Head of Mathematics). Categories were refined or expanded to accommodate any different responses. Finally, the names of the themes were refined to reflect the underlying *institutional practice*.

Institutional Practices at Cassowary Secondary College

Cassowary Secondary College is a mid-sized (875 students in 2019) co-educational government school in an outer metropolitan area of Brisbane. The school ICSEA value in 2019 was 955, with 82% of students from backgrounds below the Australian median for Socio-Educational Advantage (including 49% in the bottom quarter). Nine percent of students were from Indigenous backgrounds and 10% were from a language background other than English (https://www.myschool.edu.au/). Student enrolments in Mathematics B in Year 12 were 28 in 2013 and 36 in 2017 (ratio: 1.29) while the school population increased from 910 to 955 (ratio: 1.05). Thus, there had been an increase in enrolment in Mathematics B in the context of a relatively stable student population.

Six institutional practices that may contribute to sustained increase in enrolments in Mathematics B were identified and grouped under two programs operating in the school: the Mathematics

Program and the Pastoral Care Program. Four of the institutional practices were related to the Mathematics Program and the two remaining institutional practices were part of the Pastoral Care Program (see Table 1).

Table 1

Institutional Practices Contributing to Sustained Engagement in Mathematics

School program	Institutional practice
Mathematics Program	Staffing of extension classes
	Selecting students for extension classes
	Supporting students' mathematical learning
	Providing access to resources
Pastoral Care Program	Building relationships
	Providing support networks

Mathematics Program

The Mathematics Program at Cassowary Secondary College employs a version of streaming that is characterised by providing students with opportunities to achieve their full potential: "a lot of our kids that go to extension classes would not be in traditional extension classes" at other schools (Craig, June 2019). The school usually has one Year 7 Extension class and two Extension classes in Year 8 and Year 9. In addition to extension and Core classes, there are two Horizon classes in Year 7 and one in Year 8. These classes are for students who have "too many gaps in mathematics" (Elizabeth, June 2019) and the goal is for these students to be able to transition into Year 9 or Year 10 Core classes. There appear to be four features of the Mathematics Program that potentially contribute to developing students' aspirations for mathematics: *staffing of extension classes*, *selection of students for extension classes*, *supporting students' mathematical learning*, and *providing access to resources*.

Staffing of extension classes. Craig and Elizabeth ensure that all the extension classes are taught by experienced and qualified mathematics teachers to ensure that students are well-prepared to study Mathematics B and possibly Mathematics C (a subject similar to Specialist Mathematics that can be taken alongside Mathematics B). According to Craig, the school has "good teachers … We do put them on our extension classes and our senior classes … that's very deliberate … it's very hard to extend kids if you don't know where you are extending them to" (Craig, June 2019). Elizabeth provided further explanation of the rationale for this approach:

> We put very experienced teachers in those [extension] classes. Teachers who are teaching senior maths like Maths B, Maths C. We give them these extension classes because they know where they have to lead these kids to, what skills are very important, say like algebra skills, the first thing for Maths B, Maths C, problem solving. By the time the kids are in 10 extension—so we have a good group who is going to Maths B class—they feel confident. (Elizabeth, June 2019)

This approach is not at the expense of providing quality mathematics teaching for all students: "We have other teachers who are exceptional at working with students who need support" (Craig, June 2019). There are some teachers in the school who were trained as primary teachers and moved to Cassowary Secondary College when Year 7 moved from primary to secondary schooling in Queensland. One of these teachers takes the Year 7 Extension class for both mathematics and science. Teachers taking the Year 8 and Year 9 Extension classes are "maths teachers who are trained to be maths teachers" (Elizabeth, June 2019). Students in Extension classes have the same teacher in Year 8 and Year 9.

Selecting students for extension classes. When students enter Cassowary Secondary College, they may be allocated to a Year 7 Extension Mathematics class based on their results in Year 5, Year 6, and numeracy in the National Assessment Plan—Literacy and Numeracy (NAPLAN). These students "might not be very extended or super genius in maths, but they're good kids, they're hard-working kids" (Elizabeth, June 2019). Students with potential are identified during Year 7 and a second Extension class is added for Year 8. The two Extension classes continue in Year 9 and, if warranted, Year 10: for Year 9 in 2019, "we've very deliberately kept two extension classes. So even though the kids aren't quite at that level, we push them, extend them" (Craig, June 2019). The make-up of the extension classes is not static with a review at least at the end of every term:

> You're never pigeonholed in … they can move. If they're doing well in Core, we will move them up. If we find they're really struggling in maths, then we'll move them down. If it's just a lack of work ethic, we try to push them harder. (Craig, June 2019)

Craig believes that the groundwork laid through the extension program is effective: by the time students get to Year 11, "we've done a lot of work with them, and they get there and they're pretty successful at getting through" (Craig, June 2019).

For entry into Mathematics B and Mathematics C in Year 11, students need to obtain an A or B in Year 10 Extension mathematics. The school runs a Summer School in the last two weeks at the end of Year 10 to give students every opportunity to demonstrate the required knowledge and skills if they did not meet this prerequisite.

Supporting students' mathematical learning. The school has a Homework Club that operates twice a week for one hour after school: "Lots of students go there. Lots of teachers. Nearly every maths teacher is there" (Elizabeth, June 2019). Homework Club provides an opportunity for students to get assistance with concepts but also provides an opportunity to engage in mathematics beyond what students do in their usual mathematics classes: "We've had extension groups and instead of being normal Homework Club, we would sit them in a room and give them a bit of food and just do some really hard problem solving" (Craig, June 2019).

Providing access to resources. Lack of access to textbooks and technological resources to support mathematics learning presents a challenge that the school is slowly addressing. Resources are being built up over time. Class sets of textbooks have been purchased by Elizabeth since she came to the school four years ago: "I was looking after junior maths and every year I was buying a set or two class sets for extension classes. Now, all extension classes have enough textbooks in the library so they can borrow" (November 2019). Most students now have access to graphics calculators: "one year we saved money, and we bought two sets of 25 calculators for the library, and last year I have organised the borrowing system so students can borrow a calculator for a year" (Elizabeth, November 2019). While the issue of access to textbooks and graphics calculators is being addressed, access to computers is still problematic: "We are very under-resourced with computers. We have three computer rooms, four computer rooms and three of them are permanently booked so it's literally impossible to get into a computer room" (Elizabeth, November 2019).

Pastoral Care Program

The Pastoral Care Program at Cassowary State College includes a vertical house structure that focusses on *building relationships* between students and teachers and *providing support networks* such as Breakfast Club, and access to a wide range of professional support services. This program means that "school is a happy and safe place for many kids" (Elizabeth, June 2019).

Building relationships. The house system has four houses, each with four house leaders who are heads of department or experienced senior teachers. House leaders oversee three care classes which may have "20 students—there will be Year 7 students, Year 8 students, some Year 9, some Year 10 and some Year 11, 12" (Elizabeth, June 2019). Thus, house leaders are responsible for about 60

students who represent all year levels. A teacher conducts the day-to-day activities of each Care class and is supported the house leader: "I visit them every morning, wishing them good morning, asking how they been. If there are any issues, concerns, so I have to address it" (Elizabeth, June 2019). Students stay in the same Care class from the time they enter the school in Year 7 until they leave the school, thereby creating a close-knit group: "Every year three, four new students come and it's like little families. That's very good" (Elizabeth, June 2019). The major benefit of this approach are the relationships that are built: "When they're having those conversations [about future subject choices] so there is some buy in because of the relationships that are formed. As well as that, there is buy in from the parents" (Craig, June 2019).

Providing support networks. The school is acutely aware of the need to support students' physical and emotional wellbeing:

> "Some of what happens to our students outside school is horrendous, absolutely horrendous, what they live through. Without that support, they just wouldn't be able to come in and engage but with that support, thankfully they can get to school, and they can engage and be a little bit successful" (Craig, June 2019).

Although Craig acknowledged that it was unlikely that students he was referring to in this instance would be in Extension classes, the concern for these students was indicative of the culture of the school. In addition to professional support provided by a nurse and guidance counsellor, the schools pays

> for an extra guidance officer. Youth support coordinator, we pay a fairly large proportion of them, like maybe 50% … We've got two chaplains that we work hard to keep. So yeah, we are aware of the support needs but the big thing is our focus on learning … The other stuff, having good behaviour management or having lots of support networks is about supporting them to learn (Craig, June 2019)

Another way students are supported is through the provision of food. Breakfast is provided four days a week and students can get lunch if needed: "For some of our kids that's their meal for the day … We also provide lunch so if they rock up and haven't got food, staffrooms will have cheese toasties" (Craig, June 2019).

Discussion

The person-in-context perspective provided by Rogoff's (1995) personal, social, and institutional planes of analysis has allowed a focus on institutional processes within Cassowary State College. These processes provide the context for the development of students' aspirations to study Mathematics B (now replaced by Mathematics Methods) in their final two years of schooling. The Mathematics Program and Pastoral Care Program were identified as potentially making a positive contribution to these aspirations.

The structure and staffing of the Mathematics Program coupled with opportunities for students to participate in extension classes, support for students' mathematical learning and the provision of resources provide a positive mathematics experience for students. There are many similarities between the Mathematics Program and the one at Marigold State High School—a school in a low SES area that had also shown a sustained increase in enrolments in mathematics B (see Bennison, et al., 2018). Both programs began with a single Year 7 Extension class with a second Extension class added for Year 8, Year 9, and Year 10. In both cases, therefore, as many students as possible were given the opportunity to follow a pathway to Mathematics B. There were also opportunities for students to move from Core classes to Extension classes, although this flexibility was spelt out much more clearly at Cassowary State College. Staffing of Extension classes in both schools was strategic with fully qualified mathematics teachers taking Extension classes as well as senior classes. The rationale for staffing choices was similar—to provide an accessible pathway to Mathematics B for students. Unsurprisingly, access to textbooks and technology (e.g., computers and graphics calculators) was an issue in both schools but the Heads of Department had worked hard at overcoming this issue. Interestingly, Marigold State High School had established a STEM program

several years ago to encourage students to study mathematics and science whereas Cassowary State College had decided to do STEM-related activities within normal classes. One factor identified at Marigold State High School, not reported on here for Cassowary State College, was the positive culture of the Mathematics Department which possibly extends into the classroom to build a supportive environment. The culture of the Mathematics Department at Cassowary State College may contribute to building a supportive environment, but this would be in the context of the much broader school culture.

While the school's goal is to support student learning, there is recognition that this cannot happen if students' physical and emotional wellbeing is not addressed. Relationship building and access support networks is at the core of the Pastoral Care Program. The vertical house structure means that students can build relationships with their house leader and their Care teacher throughout their time at the school. It also provides an opportunity for older students to be role models for their younger peers. Recognition of the importance of support networks is evidenced by the school contributing financially to provision of extra services and ensuring that students whose access to basic necessities is limited are provided with food.

While the focus in this paper is at the *institutional* level, there is evidence of elements of Rogoff's (1995) *interpersonal* plane at work, particularly in the Pastoral Care Program. Analysis of interviews with teachers of the extension classes will shed further light on this plane. Additionally, focus group interviews with students will contribute to understanding the *social*, and *personal* plane. One of the limitations of this study is its size and scope. Data were collected in a single school at two points in time over a 6-month period. While the findings are promising, further research is needed.

Concluding Remarks

Calls for high levels of participation and success in Science, Technology, Engineering and Mathematics (STEM) by all Australians (Office of the Chief Scientist, 2014) exacerbates the need for research into improving participation and achievement in mathematics by students from disadvantaged backgrounds (Vale et al., 2020). Lower participation rates in more challenging mathematics subjects, such as Mathematics Methods, in the senior years of schooling (e.g., Murphy, 2018), means that students from disadvantaged backgrounds have narrower post-school options than their peers from more affluent backgrounds. It is crucial, therefore, to identify factors that appear to contribute to promoting sustained interest and engagement in mathematics among students from disadvantaged backgrounds. One approach, as taken in this study, is to identify schools located in low SES areas that have shown sustained increase in enrolments in these subjects and investigate personal, social, and institutional processes that may influence students' subject choices.

The case study presented in this paper focusses on institutional processes at Cassowary State College and suggests that the Mathematics Program and Pastoral Care Program have contributed to a sustained increase in enrolments in Mathematics B in this school. The findings are largely consistent with earlier research (Bennison et al, 2018) and point to possible ways that institutional practices in schools in low SES areas can promote positive aspirations for mathematics. Further research is needed to explore practices in other schools in low SES areas that have demonstrated similar sustained increases in enrolments in Mathematics Methods (which has replaced Mathematics B), including through longitudinal studies that follow students from their entry into Year 7 until these students make subject choices for the senior phase of schooling.

Acknowledgements

This study was supported by an Early Career Researcher Grant from the Faculty of Science, Humanities, Engineering, and Education. The author thanks participants for their contributions to the study.

References

Australian Curriculum, Assessment and Reporting Authority. (2015). *What does the ICSEA value mean?* ACARA. https://docs.acara.edu.au/resources/About_icsea_2014.pdf

Bennison, A., Goos, M., & Bielinski, D. (2018). Identifying practices that promote engagement with mathematics among students from disadvantaged backgrounds. In J. Hunter, P. Perger, P., & L. Darragh (Eds.), *Making waves, opening spaces. Proceedings of the 41st annual conference of the Mathematics Education Research Group of Australasia* (pp. 154–161). MERGA.

Department of Education (2022). *Why is STEM important?* https://www.education.gov.au/australian-curriculum/national-stem-education-resources-toolkit/introductory-material-what-stem/why-stem-important

Education Council (2015). *National School STEM Education Strategy 2016–2026*. https://www.education.gov.au/education-ministers-meeting/resources/national-stem-school-education-strategy

Murphy, S. (2018). School location and socio-economic status and patterns of participation and achievement in Year 12 enabling mathematics. In J. Hunter, P. Perger, & L. Darragh (Eds.), *Making waves, opening spaces. Proceedings of the 41st annual conference of the Mathematics Education Research Group of Australasia* (pp. 583–590). Auckland: MERGA.

Office of the Chief Scientist (2014). *Science, technology, engineering and mathematics: Australia's future*. Australian Government. http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf

Rogoff, B. (1995). Observing sociocultural activities on three planes: Participatory appropriation, guided appropriation and apprenticeship. In J. V. Wertsch, P. Del Rio, & A. Alverez (Eds.), *Sociocultural studies of mind* (pp. 139–164). Cambridge University Press.

Silverman, D. (2013). *Doing qualitative research* (4th ed.). Sage.

Stake, R. (2003). Case Studies. In N. Denzin, & Y. Lincoln (Eds.), *Strategies of qualitative inquiry* (2nd ed., pp. 134–164). Sage.

Thomson, S., De Bortoli, L., Underwood, C., & Schmid, M. (2020). *PISA 2018: Reporting Australia's results. Volume II: Student and school characteristics*. Melbourne: Australian Council for Educational Research (ACER). https://research.acer.edu.au/ozpisa/49

Vale, C., Averill, R., Hall, J., Forgasz, H., & Leder, G. (2020). Equity, social justice, and ethics. In J. Way, C. Attard, J. Anderson, J. Bobis, H. McMaster, & K. Cartwright (Eds.), *Research in mathematics education in Australasia 2016–2019* (pp. 177–208). Springer.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge University Press.