Practices contributing to Mathematics success in a low socioeconomic rural Victorian school

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Mathematics education is seen as a right for all children, and important to ensure a prosperous future. However, in Australia and other nations, rural students perform less well in mathematics, and are less likely to pursue advanced mathematics. This paper presents a case study of an Australian rural school that has high engagement and achievement in senior mathematics, despite its setting. The study uses a practice architectures framework to explore the activities and facilitatory elements that have likely contributed to the school's mathematics success. Personalising learning, valuing mathematics, building teacher capacity, and linking to careers, were all associated with the school's higher than expected mathematics performance.

In our technocentric world, a deep understanding of mathematics is seen as a right for all citizens (Center for Curriculum Redesign, 2013), and there is a call for a workforce with strong mathematics skills and associated skills in data analysis, coding and engineering (Australian Industry Group, 2015; Morgan & Kirby, 2016). At the same time, many nations, including the United States of America, the United Kingdom and Australia, have experienced low student participation and achievement in mathematics (Marginson et al., 2013). This deficit is even more pronounced amongst rural students. In Australia, metropolitan Year 8 students significantly outperform their non-metropolitan counterparts in mathematics (Thomson, Wernert, O'Grady, & Rodrigues, 2017). In Victoria, when completing the Victorian Certificate of Education (VCE), rural students are less likely to participate in advanced mathematics subjects, such as Specialist Mathematics and Mathematical Methods, and more likely to enrol in elementary mathematics subjects, such as Further Mathematics (Murphy, 2018). Further, metropolitan students outperform students attending rural schools in all VCE mathematics subjects (Murphy, 2018).

Research suggests the reasons for this deficit are varied. Some studies suggest rural students feel less competent and less engaged in mathematics, and that their mathematics teachers are less supportive (Hardre, 2011). Rural students and their parents tend to have lower educational aspirations (Centre for Education Statistics and Evaluation, 2013), so may be less likely to pursue mathematics as a pathway to further study. It is also difficult to recruit and retain qualified mathematics teachers in rural areas, and to provide these teachers with appropriate professional learning (McPhan & Tobias, 2011). There are strategies that are known to be effective in addressing issues of student engagement in mathematics and mathematics teacher capacity, such as differentiated instruction (Prast, Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2015), engaging pedagogical repertoires (Attard, 2014), and models of professional learning in mathematics (Watson, Beswick, & Brown, 2012). However, there is scant evidence regarding what may be effective in improving school-wide mathematics education in rural contexts.

This paper addresses this shortfall. It presents a case study of a rural Victorian school, referred to as Sweeping Plains College (SPC) in this paper, that has had sustained high participation and high achievement in VCE mathematics. It explores the mathematics education practices of SPC, addressing the research question, "What mathematics education practices might have contributed to the sustained mathematics success of SPC?"

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Method

Conceptual Framework

In order to explore the complex interplay of the various practices influencing the school's mathematics success, practice architecture was used as a conceptual framework to guide data collection and analysis. Practice architecture sees practices as comprised of 'saying', 'doing' and 'relating' actions (Kemmis, 2008). These actions influence, and are influenced by, the cultural-discursive structures of language, the material-economic structures of work and resourcing, and the socio-political structures of power and relationships, that make up practice architectures (Kemmis, 2008). Using a practice architecture lens, the various activities possibly contributing to SPC's mathematics success were examined, as well as the structures that constrain and enable these activities.

Case Selection

Schools vary in their average enrolment proportions and achievement levels in VCE mathematics subjects (Murphy, 2018). Using Year 12 VCE participation and achievement data, SPC was selected for study as a rural school with high mean mathematics enrolment proportions (out of all VCE subjects undertaken), and high mathematics study scores (standardised scores out of 50 with a median of 30) (see Table 1). SPC's enrolment proportions and study scores in mathematics were consistently high across all three years.

Table 1
Mean enrolment proportions and study scores out of 50 from 2014-2016 at SPC and all schools

	Sweeping Plains College		All Victorian government schools	
Mathematics Subject	Mean enrolment proportion	Mean study score[a]	Mean enrolment proportion	Mean study score[a]
Further Mathematics	11.02%	31.00	12.19%	27.76
Mathematical Methods	7.87%	30.40	4.54%	26.04
Specialist Mathematics	2.36%	34.00	1.44%	26.19

[a] VCE study scores are standardised scores out of 50 with a median of 30.

Participants

The principal, Ken, as well as six teachers teaching across mathematics, science and technology subjects at various year levels (Karen, Adrian, Lilly, Paul, Georgia, and Craig), gave consent to be interviewed. Six female and six male students currently studying VCE Science, Technology, Engineering and Mathematics (STEM) gave consent to be interviewed.

Data Collection

Data were collected from various sources. School level quantitative data were obtained about participation and achievement in VCE subjects in 2014, 2015 and 2016 from the Victorian Department of Education and Training (DET). Publicly available National Assessment Program – Literacy and Numeracy (NAPLAN) data for the relevant cohorts were extracted from the MySchools website. Qualitative data were gathered during site visits through semi-structured interviews with participants (Gideon & Moskos, 2012). The paper reports on one aspect of a project investigating rural school STEM success. The teachers and the principal were interviewed individually, and were asked open-ended questions about perceived contributors and impediments to STEM education success at the school. Students were interviewed as a group and asked open-ended questions about their learning experiences and participation in STEM. All interviews took place in the school's careers room and varied in length from 20 – 40 minutes. The interviews were recorded and transcribed, and the transcripts were used for analysis. The school's annual report, college profile and philosophy, student subject selection booklet, and timetable were also collected for analysis. The researcher also toured the school accompanied by the principal, taking field notes and photographs of resources, displays and facilities.

Case Analysis

Using a practice architecture conceptual framework, an explanation-building approach to analysis was employed for the case analysis (Yin, 2014), where a set of causal links were sought to explain how and why SPC had achieved its mathematics education success. Qualitative data were analysed using thematic analysis (Braun & Clarke, 2006). Data were coded using both deductive and inductive themes (Braun & Clarke). Initially data were coded into practice activity (sayings, doings, or relatings) or practice architecture (cultural-discursive, material-economic, or socio-political) categories. Following this, through iterative engagement with data coded as relating to practices and practice architectures, inductive themes were identified, a process Braun and Clarke described as "organic thematic analysis" (p. 741). Six themes emerged through this process: differentiated instruction in mathematics, valuing mathematics, building teacher capacity, careers education, vocational education and training, and community connections. The quantitative data were analysed descriptively to corroborate and extend understandings gained from the qualitative data sources. The use of multiple sources of qualitative and quantitative data allowed for triangulation of findings (Yin, 2014), enhancing the overall credibility of the study (Tracy, 2010).

Case Study

School Context

SPC is a rural co-educational P-12 school with 136 students in 2016, 41% of whom are in the primary school, and 59% in the secondary school. 5% of students identified as Indigenous Australian or Torres Strait Islander, and 1% had a language background other than English. The Index of Community Socio-Educational Advantage for the school was 963 (MySchool website), below the standardised national mean of 1000. SPC serves a stable farming community more than 200 kilometres from Melbourne and more than 100 kilometres from the closest regional city. The nearest independent secondary school is approximately 1 hour and 20 minutes' drive away; however, there are five other government secondary schools within a 30 minute drive. These government schools collaborate as part of a network, sharing resources including the Technical Trade Centre (TTC) built on SPC's site.

Cohort Profile

From 2014-2016, a total of 25 students completed VCE at SPC, with a mean study score of 31.7 across all Year 12 VCE subjects. Table 1 shows that this cohort's achievement levels were well above the state average in all mathematics subjects. The enrolment proportions were well above state average in Mathematical Methods, and Specialist Mathematics, and slightly below state average in Further Mathematics, counter to the trend of rural students choosing less advanced mathematics (Murphy, 2018). NAPLAN data show that in Year 5 this cohort's results were similar to the state average in numeracy (489 compared to 492) but above state average in Year 7 (571 compared to 551) and in Year 9 (616 compared to 604). SPC attracts additional enrolments at the beginning of secondary school, causing an average 67% increase in student numbers from Year 6 to Year 7, which may account for the improvement in Year 7.

School Mathematics Programs

SPC's mathematics education is delivered through non-integrated mathematics classes, similar to in most Australian schools (Marginson et al., 2013). However, SPC's students spend more time studying mathematics. In the primary school, SPC students study 280 hours of numeracy each year, compared to an average of 202 hours for Australian Year 4s, and from Year 7 to 9 they study 187 hours of mathematics, whereas the average Australian Year 8 student studies 139 hours (Thomson et al., 2017). Given the small school size, there is only one class group at each year level. Year 9 and 10 mathematics lessons are taught together by two teachers, with students grouped by ability and studying either a standard mathematics program or accelerated VCE General Mathematics. Each year from 2014-2016 SPC ran all three Year 12 mathematics subjects shown in Table 1, something increasingly rare in rural schools (Murphy, 2018).

Mathematics Education Practices contributing to SPC's mathematics success

While the broader research project this case study forms part of explored STEM education, thematic analysis of SPC interviews revealed a common focus on mathematics education. Of the themes to emerge, two - differentiation in mathematics, and valuing mathematics - were specific to mathematics education. Three practices, teacher capacity, careers education, and vocational education and training, were seen as impacting significantly on mathematics education at the school. The following sections explore practices captured by these five themes.

Differentiation in Mathematics

SPC teachers used a variety of strategies to differentiate learning to meet each student's needs in mathematics. From Year 4 on, the mathematics program involves students taking ownership of their learning and working in flexible arrangements at their own ability level and pace. Karen explained, *"They're building at a very early age that knowledge of, 'okay there is more to learn and I can', and building that independence and actually working towards achieving their goals and learning more and more".*

Pre-testing is used to help students set learning goals and they then access their learning program via Google classroom. The teachers make use of online videos, software, activities, games and small group instruction to resource the program and support student learning. Karen said, *"It's all up on the Google classroom page and the kids just follow through. So on [the] Google classroom page it says watch the clip below, and if they understand that they can just go on and do the work. If they don't understand it, they'll come and seek support from one of the teachers in the room. Or it might say you need to go and do a focus with the teacher".*

Student learning is monitored publicly. Karen described this, *"All their learning intentions [are] on a grid for the kids to see. It's a visual thing with their name on the bottom, [they] colour in what they can do… and their goals are in a light colour... And they just go from one skill to the next as they progress… So today when I wrote on the board, I* *had I think about nine different things that people were doing in a classroom of… about 20 kids".*

Several students commented positively about the differentiated mathematics instruction in the middle years. One student said, *"You wouldn't have to be doing things with kids that were at a lower level of maths and you would be able to learn the things that you needed to rather than keep going over the same sort of stuff that another group wouldn't be at".*

In Year 10 many students at SPC accelerate into Year 11 level VCE General Mathematics. This transition option is seen as providing a good opportunity for advanced students, as well as facilitating more effective support for students finding mathematics more difficult. Students continue to receive differentiated support through their senior years; however, this is more often through additional out-of-class assistance.

Both teachers and students felt that the small size of the school and STEM classes, particularly in VCE, made understanding and responding to each student's learning needs more achievable. Somewhat related, the closeness of relationships between staff and students and families at SPC was seen as contributing positively to the school's mathematics education success. Adrian commented, *"Because of that intimacy of the relationships between the students and the staff and the whole community, just supporting everybody and being able to know that if you want to do something there's always people there to help you, and support".*

Valuing Mathematics

The teachers also invest significant effort into encouraging students and their families to value mathematics and mathematics education. Regular mathematics columns in the school newsletter promote mathematics activities and the achievement of students. Fortnightly mathematics awards are presented at school assemblies for effort and achievement. Students are supported to participate in a diversity of external mathematics competitions and activities. Every few years SPC hosts a whole school mathematics day. These activities are seen as enhancing the valuing of mathematics by students and parents.

The utility value of mathematics education is also emphasised. There is a focus on explaining how each aspect of mathematics is used in the real world. Adrian said, *"I think as teachers, when we teach maths… we always try to use real-life situations for problem-solving".* Karen and Craig spoke about explicitly writing on the board why students are learning the mathematics that is the focus of that particular lesson. Various teachers spoke about adjusting their mathematics learning programs to respond to student interest in taxation, finances and farming, noting that students saw the relevance of these real world contexts and thus were *"really engaged and interested".* The students felt this practice made the mathematics more relevant and easier to learn. One student said, *"She'd relate it back to real life as well so it made it more relatable".* Another comment was, *"He just related it back to real life, which always makes things a lot easier to remember".*

In addition to exploring the real world applications of mathematics, the staff also emphasise the utility value of studying mathematics for accessing further study and/or particular careers. Georgia offered this reflection on this pragmatic approach, *"Whatever you do you're going to need the maths, so there's got to be something that you have to, not necessarily enjoy, but at least persevere with… the fact that most of our kids do VCE maths, … the majority of them can see that maths is going to be involved in their job, some sort of maths".*

Teacher Capacity

The mathematics teachers at the school are regarded as strong, passionate educators. Karen said, "*You've got to have people on the ground that are passionate and can share their passion with the kids I think, yeah".* A student, describing her previous mathematics teachers said, "*They were just very well educated themselves and just really good at explaining to other students what they were trying to get".*

The school invests in building the capacity of its mathematics teachers through a range of mechanisms. The mathematics staff regularly meet as a numeracy professional learning community (PLC) where they engage in targeted professional learning activities to meet school needs. Sometimes the PLC explores particular mathematics content, such as word problems and numeracy fluency; at other times they consider the mathematics learning needs of particular students. Karen illustrated this, *"This is the student I've got and this is their background and this is what I'm struggling with… What I want is an idea about what I can do, and things like that".* The numeracy PLC also strategically pursue external professional development to help meet the needs of their students; for example, having multiple staff trained in the Quicksmart program in response to concerns about the numeracy fluency of their middle school students.

Teachers are also well supported to pursue their own professional learning (PL) interests. Ken said, *"We encourage our staff to undertake a lot of PD, particularly senior teachers, maths teachers, et cetera".* Teachers agreed they had good support to attend PL, and Georgia noted that accessing PL was much easier at SPC than at her previous school. Several teachers cited PL they had recently attended, but they also noted the difficulty of time and travel associated with accessing this PL. When available, the mathematics team engages with closer PL opportunities organised by schools in their network. There is an obligation on those who attend professional development to report back through the numeracy PLC. There are also informal PL opportunities. Georgia noted, *"If we have questions, [we] can get together 'cause there's only a handful of us anywa.."* Timetable arrangements also provide opportunities for team teaching in mathematics from Years 4-6 and again in Year 9 and 10. Further, the flow of numeracy expertise between the primary and secondary schools is enhanced by some mathematics teachers teaching in both areas.

Careers Education and Vocational Education and Training (VET).

Thematic analysis identified two further themes contributing to mathematics education at SPC: Careers education and VET. Both these themes were seen as particularly contributing to student engagement and participation in mathematics. The school runs an extensive careers program beginning in Year 7. Both staff and students spoke about this program contributing to the students' understanding of mathematics pathways and careers. Ken explained, *"That really, I think, supports students when they're making choices for subjects entering into VCE, there's great knowledge there and recommendation regarding the need for your maths subjects for example, depending on what their career choices might be".*

The extensive VET program offered by the school in the TTC was also seen as highlighting the utility value of mathematics as well as reinforcing numeracy skills. All Year 9 and 10 students spend one day each week in the TTC, where they choose from an array of subjects, most of which are STEM related such as Agriculture, Allied Health, Animal Studies, Automotive, Building and Construction, Engineering, Games Design, Kitchen Operations, and Textiles. Paul spoke about the role of mathematics in the VET program, *"You've got to include numeracy everywhere… Numeracy is paramount. So it's imperative that the students, especially in engineering, have numeracy competency".*

Participants also referred to farming and other local industries highlighting the utility value of mathematics for students. Interestingly, some also highlighted SPC's isolation and decreasing local employment opportunities as a potential motivator for students to do well in mathematics in order to seek study and employment elsewhere.

Discussion and conclusion

SPC is a school that has sustained high enrolment proportions and achievement levels in senior mathematics subjects, despite its rural location. Practice architecture was used as a conceptual framework for analysing the educational practices associated with this mathematics success. This analysis produced five key themes related to mathematics education: differentiation in mathematics, valuing mathematics, teacher capacity, careers education, and vocational education and training.

SPC students spend many more hours studying mathematics than the national average (Thomson et al., 2017), although, in the literature, there appears to be no association between instructional time and achievement in mathematics in Australia (Baker, Fabrega, Galindo, & Mishook, 2004). The particular practices at SPC appear to have a positive impact on its students' achievement and engagement in mathematics. Differentiated instruction in mathematics, as implemented at SPC, has been shown to impact positively on student achievement (Prast, Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2018). The cycle of pretesting, goal setting, individualised instruction and practice, and post-testing in middle year's mathematics at SPC matches the cycle of differentiation espoused by mathematics education experts (Prast, Van de Weijer-Bergsma, Kroesbergen, & Van Luit, 2015). In combination, the differentiated instruction at SPC, facilitated by embedded technology and incorporating student self-direction, combined with SPC's practices highlighting the value of mathematics, might be viewed as an example of Attard's engaging pedagogical repertoires for mathematics (Attard, 2014). More broadly, SPC's practices build student self-efficacy, student valuing of mathematics, and parent interest in mathematics, all factors that are known to contribute to student engagement and 'future intent' towards mathematics (Martin, Anderson, Bobis, Way, & Vellar, 2012).

Recruitment difficulties and high turnover of mathematics teachers does not seem to have impacted SPC in recent years, as they have other rural schools (McPhan & Tobias, 2011), with several long-term mathematics teachers and the mathematics teachers regarded as strong educators by the school community. The mathematics teachers at SPC were seen by their students as strongly supportive, counter to Hardre's (2011) findings regarding rural mathematics teachers. SPC's numeracy PLC's approach to professional learning includes many of the elements of effective mathematics PL described by Waston, Beswick and Brown (2012). PL in mathematics at SPC centres on the school's students' learning needs, as identified by the teachers who know them, and draws on external expertise as required. In addition to this collective approach, teachers are supported to pursue their own PL interests in mathematics.

A limitation of this study is that the entire cohort whose performance was the basis for choosing SPC for study was only 25 students. Although unlikely, it is possible that SPC's 'mathematics success' was due to individual student rather than school based factors. However, even if this was the case, the identified practices provide a valuable illustration of how the mathematics engagement and achievement of this cohort was maintained and developed.

SPC is a case of a rural school where an array of mathematics practices appear to have contributed to very-high, sustained senior mathematics performance. Mathematics education, like all school practices, is comprised of a complex array of situated activities, and the cultural, material and social structures that shape them (Kemmis, 2008), which are likely to be unique to each school community. Given this, this case study does not describe a generalisable approach to be adopted by other schools. Rather it provides transferable insights into how mathematics education practices may be used to foster increased participation and achievement in senior mathematics education, particularly in small rural schools. Further investigation of the mathematics practices in other successful rural schools, and comparing these to less successful rural schools, could deepen this understanding, offering more guidance to rural school practitioners and policymakers hoping to close the mathematics performance gap between metropolitan and rural schools.

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