A primary education mathematics initiative in an Indigenous community school

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This study investigated the implementation of a primary mathematics initiative in an Australian Indigenous community school designed to improve students' mathematical proficiency. Throughout the 7-month initiative, four classes ranging from Year 2 to Year 6 participated in the initiative. Findings indicated an increase in mathematics achievement as measured by the Progressive Achievement Test – Mathematics (PAT-M) throughout the initiative. As the findings from the Year 3/4 class displayed the largest growth in mathematical achievement throughout the initiative (equivalent to 1 year and 2 months), the specific pedagogies and practices enacted in this class that were found to influence students' achievement will be considered.

The gap in achievement between Indigenous and non-Indigenous students in Australia is regularly referred to in literature, and there has been little change in this gap over time despite several initiatives, both government and non-government, attempting to address these reported gaps (e.g., Dreise & Thomson, 2014; Thomson et al., 2016). Though the Council of Australian Governments (COAG) goal to halve gaps in numeracy achievement for Indigenous students by 2018 has not been realised (Department of the Prime Minister and Cabinet, 2018), this paper will discuss a case where the gap between Indigenous students' and non-Indigenous students, as measured by PAT-M, had been successfully reduced in a sample within one Australian Indigenous community school.

Literature Review

A substantial body of research in Indigenous education focused on achievement has been established in recent decades and continues to be of importance due to equity implications (Hunter & Schwab, 2003). Beyond conforming ideals of creating capable citizens, whereby mathematical knowledge enables students to understand how the world works, those who develop mathematical knowledge potentially have the capacity to also create the world in a new way (Atweh & Brady, 2009). Due to equity concerns and the importance of mathematical knowledge, research exploring effective education practices in Indigenous education is important as "future Indigenous education policy decisions must be based upon real research findings, and where these findings necessitate policy action, those actions must be taken" (Mellor & Corrigan, 2004, p. iv). These sentiments have also been re-iterated in reports on Indigenous primary school achievement by the Productivity Commission (2016).

Despite several programs focused on Indigenous mathematics education currently operating across Australia, no consistent improvement has been realised according to current large-scale, standardised measures of achievement (e.g., the National Assessment Program – Literacy and Numeracy [NAPLAN], Programme for International Student Assessment [PISA], and Trends in International Mathematics and Science Study [TIMSS]). Therefore, it is important to continue investigating the impact of specific educational practices to further understand underlying reasons for these gaps and to focus on identifying and supporting teachers in implementing successful practices. This study is significant for its contribution to our understanding of these issues, and the findings reported focus on the practices enacted

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by teachers, supported by the researcher in the role of a mentor, that resulted in significant positive change in students’ mathematics achievement as measured by the PAT-M.

A summary of seminal literature regarding effective teaching of mathematics to disadvantaged students is outlined in Table 1. These practices were also supported by common findings from research concerning effective numeracy development for Indigenous learners through the What Works program developed by the Australian Government, Department of Education, Science and Training (DEST, 2010). This literature guided the conceptualisation of the mathematics teaching initiative in the initial stages of development. The intention of the review in the development of the initiative was to establish a mathematics program that was structured in a manner that provided appropriate opportunities to thoughtfully develop foundational mathematics concepts.

Table 1
Effective pedagogies informed by literature

Initiative elements	Components of effective mathematics education from literature
Developing the initiative	High levels of teacher collaboration and a shared, school-wide approach (Boaler & Staples, 2008; Jorgensen, 2018).
Lesson elements	Explicit teaching of new mathematical concepts (Baker et al., 2002; Good & Grouws, 1979; Hattie, 2009; Jorgensen, 2018; Pegg & Graham, 2013).
	The central role of feedback, & providing feedback data to students (Baker et al., 2002; Hattie & Clarke, 2019).
	A mastery learning cycle (Hattie, 2009; Jorgensen, 2018; Kulik et al., 1990; Pegg & Graham, 2013).
	High mathematical expectations (Jorgensen, 2018).
	Focus on number (place value and operations) as a priority (Jorgensen, 2018).
Teaching number facts	Explicit strategy instruction in conjunction with timed tasks (Cumming & Elkins, 1999; Pegg & Graham, 2013).
Teaching computations/algorithms	CRA teaching sequence, and consistent language and methods for teaching algorithms (Mancl et al., 2012).
Teaching problem-solving	Utilisation of Polya’s problem solving heuristics (Ozsoy & Ataman, 2017)

One of the dominant practices focused on in this initiative was explicit instruction to conceptually develop students’ deep understanding of key mathematics concepts. Explicit instruction is “a systematic method of teaching with emphasis on proceeding in small steps, checking for student understanding, and achieving active and successful participation by all students” (Rosenshine, 1987, p. 34). Supported by evidence from meta-analyses and other studies (Hattie, 2009), explicit instruction practices have been shown to significantly increase students’ achievement. Often explicit instruction (sometimes referred to as direct instruction) is criticised due to its presumed association with a didactic teacher instructional model. To clarify, Hattie (2009) provided a list of seven elements of effective explicit instruction which consisted of clear lesson goals (learning intentions) and success criteria, student engagement, lesson structures designed to accommodate modelling and checking for understanding, guided practice, independent practice, and effective lesson closures. Many of these practices align with key practices noted in other projects involving Indigenous students (e.g., Jorgensen, 2018).

Two research questions were answered in this study by observing how teachers employed the suggested practices and by tracking changes in students’ achievement on the PAT-M. The first research question was: *How did students’ mathematical achievement, as* *measured by the PAT-M, change as a result of the initiative?* And *how did teachers implement a mathematics initiative in an Indigenous community school?*

Method

The Sample: Study context

The students in this study were of Aboriginal and Torres Strait Islander heritage, which encompasses a great diversity of people. The local context of these students was an urban community (city) in Australia. The context of the study school is a F-12 community operated school (under the banner of an Australian Independent school, which is government funded but run by a community identified school board) for Indigenous students. This study involved four composite age classes, comprising of students from Year 2 to 6 (Year 2/3, Year 3/4, Year 4/5, and Year 5/6), four individual classroom teachers, and 57 students. The findings from 11 students in the Year 3/4 cohort (out of a total class number of ~20-25 students) are reported. The final sample is smaller than the total population of the class due to students leaving the school throughout the initiative resulting in incomplete data for some students, and movement of students between classes meaning that achievement could not be tracked and attributed to the teaching and learning occurring in a single classroom. The total class numbers fluctuated in the outlined range throughout the school year due to student movement in and out of the school, and within the school. The teacher for Year 3/4, Diane (a pseudonym), was a practising teacher for approximately 15 years who had been teaching at the sample school for 12 years.

Implementation of the initiative

The mathematics initiative in this study was conducted over 7-months from March to October of the school year. The initiative was implemented through professional development sessions delivered by the researcher. The first of these sessions was run at the beginning of the initiative and involved dissemination of the summary of literature findings to teachers. The researcher then maintained an interactive role throughout the initiative by providing support to teachers when planning and implementing their mathematics programs. The interactive nature of the research was facilitated by the researchers established role as a teacher in the school prior to the initiative. The prolonged engagement of the researcher in the school helped to increase the credibility of findings, which worked to ensure the validity of conclusions from findings (Guba & Lincoln, 1985). Also, due to the researcher's pre-established role in the school, the context and culture of the school were well understood, and rapport was established with students and staff, increasing the credibility of findings by providing cultural sensitivity (Gay et al., 2006). Further professional development sessions were facilitated part-way through the initiative during school hours to provide interim analysis of class data; this was conducted in the interest of ensuring the collected data supported the school's mathematics programs in a meaningful way.

Overview of Methodology

The research design for this study was mixed methods, typified by the collection and interpretation of quantitative data, followed by qualitative data to provide breadth and depth of data to explain a complex phenomenon (Cohen et al., 2011). To address the first research question, changes to students' proficiency throughout the initiative was measured using a standardised mathematics test (PAT-M). To address the second research question, rich qualitative data in the form of classroom observations were collected throughout the initiative. The quantitative findings relating to changes in students' achievement were then connected to and explained by the qualitative classroom observations. Interpretations on how teaching practices impacted on students' mathematics achievement were then made, following a sequential mixed methods design (Creswell & Plano Clark, 2018). Though these findings are not reported within the scope of this paper, this study was situated within a larger research study which involved the collection of further data on students' mathematical proficiency (Reid O'Connor, 2020; Reid O'Connor & Norton, 2020). The use of multiple data sources and triangulation of data in this mixed methods study helped work towards increasing the trustworthiness and confirmability of findings (Guba & Lincoln, 1985).

Data analysis: Progressive Achievement Test – Mathematics

Changes to students' mathematical proficiency were measured by administering the standardised PAT-M at the beginning and conclusion of the initiative. The PAT-M consists of 30-40 multiple choice items across number, algebra, geometry, measurement, statistics, and probability. The PAT-M provides a measure of students' skill and understanding of school mathematics (Stephanou & Lindsey, 2013). The intended use of these tests aligned with this study, which aimed to assess students' current achievement, monitor the impact of an initiative over time, and to inform the development of the initiative. Utilising a standardised test also provided a method for comparing class mean scores to the national norming sample of over 500,000 students. Cohen effect sizes were also calculated to compare the initiative to the national norming sample. Effect sizes are an empirical measure that answers the question "how does the effect of an initiative compare to a typical year of growth for a given target population of students" (Hill et al., 2008, p. 173). Cohen (1988) classified effect sizes of 0.20 as small, 0.50 as medium, and 0.80 as large; other literature has found 0.40 to be the average effect size expected during a school year (Hattie, 2009). For more meaningful comparisons, the effect sizes from the norming sample data were also calculated.

Data analysis: Classroom observations

Classroom observations were carried out throughout the initiative and provided important data to identify how and why classroom practices were influencing students' achievement. Classroom observations focused on qualitatively recording: (1) lesson structures, (2) pedagogical approaches, (3) frequency and type of teacher interaction with students, and (4) student time on task. Approximately two mathematics lessons were observed in each class during each week of the initiative. Observations were recorded by the researcher as field notes in the form of diary entries throughout the initiative. The intent on such a method was to be able to tell the story of what happened in classrooms to allow for teaching practices to be described in detail and linked to student achievement. Observations of the classes during mathematics lessons also allowed for identification of other relevant occurrences in students' learning environments that may have impacted on teaching and learning. Summaries of teaching practices were member checked with teachers at the conclusion of the initiative to help ensure the authenticity and dependability of the data and analysis, increasing the validity of findings (Guba & Lincoln, 1985).

These qualitative observations were analysed by the creation of case reports for each class, and Wellington's (2015) stages for interpreting qualitative data were utilised. These stages consisted of immersion in the data and reflection, analysing and taking apart the data, and recombining and synthesising the data. Patterns in teaching practices across observations were identified relating to the four observed elements in lessons. These trends were then reduced by searching for overarching themes; for example, patterns relating to classroom routines and daily activities that fostered student's independence were grouped under an overarching theme of *consistency*. These themes were then located with reference to the literature (Wellington, 2015), to propose links between teaching practice and student achievement.

Results: PAT-M

The mean PAT-M score and effect sizes for the Year 3/4 class comparative to the national norming sample is outlined in Table 2. The comparative mean scores reported for the norming sample are what would be typically expected of a Year 3 student in March and October respectively.

At the beginning of the initiative, the mean score reported by the Year 3/4 class was below the norming sample mean. The mean score of 96 reported by Year 3/4 was equivalent to an achievement standard of an early Year 2 student when compared to the norming sample. By the end of the initiative, the Year 3/4 class reported positive gains in mean score, and closed the gap in achievement comparative to the norming sample. The Year 3/4 post-initiative mean score of 109 was indicative of an achievement standard similar to that of a mid-Year 3 student. Comparing the effect size found for Year 3/4 to Hattie's (2009) classification, the large effect size of 1.36 was above the zone of desired effects for an educational intervention.

Table 2
Results from PAT-M pre- and post-initiative for Year 3/4

	M (Mean Rasch Scaled Score)		Effect size
	Pre-initiative: March	Post-initiative: October	
Year 3/4, n=11	96.57	109.88	1.36
PAT-M norming sample	106.29 (Yr3)	110.90 (Yr3)	0.32
Gap in achievement	-9.72	-1.02	

Overall, the gains in achievement reported by the Year 3/4 cohort throughout the initiative equated to an improvement of approximately 1 year and 2 months within the 7-month initiative, twice the expected gain. Figure 1 graphically outlines the change in scores throughout the initiative.

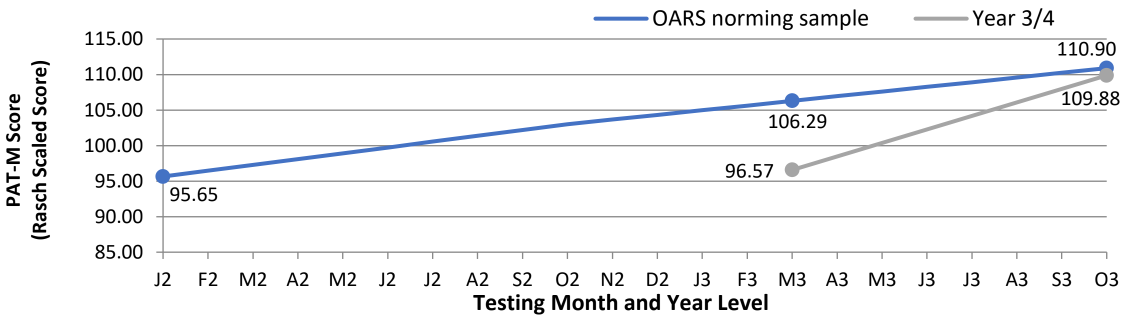

Figure 1. Graph of the growth in PAT-M achievement for Year 3/4 compared to the norming sample, n=11.

The Year 3/4 cohort experienced a more substantial improvement in a shorter timeframe than the national norming sample. The significant gains in achievement, and subsequent closing of the achievement gap, and high effect size indicated that the initiative was highly effective in advancing students' learning in this class. Exploring the pedagogical practices enacted by the classroom teacher assists in understanding why the initiative was effective in advancing students' mathematics achievement in this case.

Results: Classroom Observations

The teaching approach of the Year 3/4 teacher, Diane, involved mathematics lessons that followed a consistent daily structure, with the intention that students in the class would also learn the structure and become self-sufficient with lesson routines (i.e., students knew what activities were coming next and could get appropriately prepared without added teacher instruction). When asked to comment on her specific strength in teaching mathematics, Diane self-identified that her strength was implementing consistent routines by noting "I stick to routine quite stringently…I think that is a strength because the children know what the expectation is for the day, for the week".

In addition, Diane focused on maintaining high behavioural standards during classes as a priority, and subsequently was observed to consistently minimise behavioural interruptions that may have occurred without her supervision and guidance; this was achieved by Diane establishing a trusting and respectful rapport with students by maintaining firm, consistent, and reasonable expectations regarding classroom behaviour.

High academic standards were also a major feature of Diane's teaching approach. On a daily basis Diane constantly consulted with students one-on-one during mathematics lessons by marking students' work and giving feedback, with the expectation that students would then immediately return to independently fix any errors. This consultation and feedback process formed a continuous cycle. Feedback included supporting the students in identifying their error/s, followed by discussion and explanation of correct techniques or strategies. What Diane was observed to have implemented was a method of maintaining high academic standards through short diagnostic teaching cycles where a small number of tasks (questions or problems) were set and completed by students then checked by a teacher, and where accuracy of answers was required. This cycle is outlined in Figure 2.

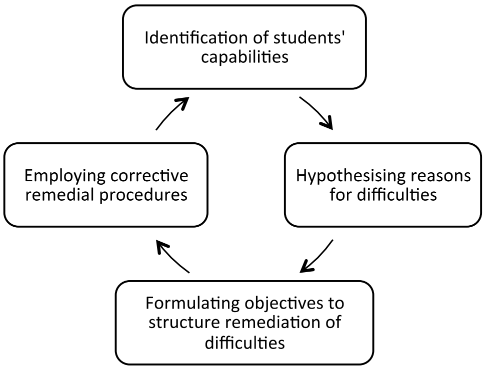

Figure 2. Description of diagnostic teaching cycle employed in Year 3/4 (developed from Reisman, 1982).

The way in which Diane influenced students' achievement in mathematics through the combination of consistent lesson structures, high behavioural standards, and high academic standards was observed to result in high levels of time on task for students in Year 3/4. The continual checking of student work and continuous feedback cycle was observed to foster a learning environment where most students strived for accuracy.

Diane's pedagogic approach focused on explicit individual and whole class instruction, and group work was not a feature of instruction. In terms of the quantity of work set, Diane set small quantities of work (i.e., questions) for students to complete as part of her diagnostic teaching cycle. Diane followed recommendations concerning the need to conceptually develop ideas at the introductory phase of learning by following the recommended, consistent pedagogy and language for teaching algorithms, however Diane focused on clear strategy discussion in mathematics. On this, Diane noted that "I always try and teach my kids other ways of doing things. There's not just one way".

Discussion

Results from this study indicated that, as measured by the PAT-M, students in the reported cohort substantially increased in their mathematical proficiency over the course of the initiative as illustrated by high effect sizes and the closing of the gap between the Indigenous students and the norming sample comparisons. Pedagogical practices supporting consistency (predictable lesson structures fostering students' self-sufficiency), feedback (in the form of a diagnostic teaching cycle), and high expectations (relating to both behaviour and academic expectations) were critical features of the teaching approach in mathematics in Year 3/4.

One potential explanation for practices associated with consistency and high expectations underpinning positive gains in students' achievement is the outcome of increased academic learning time. Research in Indigenous settings, including the Success in Remote Indigenous Contexts project (Jorgensen, 2018), has proposed that consistent lesson structures reduce student confusion, which subsequently enables students to focus on the tasks rather than guessing teacher or classroom expectations. This finding was also supported in this study as a known and consistent lesson structure fostered students' independence in their learning and reduced many classroom or behaviour-related disruptions related to students being off-task or needing to ask what was required of them. The result is that the total time students spend on task is increased.

The diagnostic teaching cycle was a central element in successfully implementing and maintaining high academic expectations within the classroom. The continuous feedback cycle fosters a mastery teaching approach which is supported by empirical research (e.g., Good & Grouws, 1979; Hattie, 2009; Hattie & Clarke, 2019; Jorgensen, 2018; Kulik et al., 1990; Pegg & Graham, 2013). This diagnostic, mastery approach increased students' experiences with success on mathematical tasks in the observed class. Feedback through the diagnostic cycle achieves a meaningful and practical way for the teacher to ascertain what students understand and what mistakes they are making, and through this process teaching and instruction can be accurately tailored. By doing this, teaching is never "missing the mark" of where students are at in their learning process, and instruction can be tailored to ensure it is highly relevant and appropriate to students' ability and learning needs.

Overall, the enacted practices in this class that were supported by the initial literature review including consistency, mastery teaching approaches, feedback, and high expectations were successful in raising Indigenous students' mathematical achievement throughout this initiative.

Conclusions

The positive findings from this study relating to Indigenous students' achievement is an important contribution to literature, particularly due to the wealth of deficit-based findings that are currently reported in the field related to large-scale standardised testing. Whilst the findings of the larger study from this initiative indicated that the factors relating to Indigenous students' mathematical proficiency in this setting were complex and inter-related, with several affective factors playing a critical role (Reid O'Connor, 2020), the conclusion from the initiative's findings were that positively influencing Indigenous students' achievement is a worthwhile and feasible endeavour. Specific practices supported by the findings that positively influenced students' mathematical proficiency included consistent lesson structures, short and targeted diagnostic teaching cycles featuring high levels of feedback, a mastery approach, and high expectations within a framework of classroom management that worked to maximise learning time. Further studies are needed to explore the impact of these practices in other Indigenous school settings, and the limitations of this study include the small sample size.

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