Overcoming Challenges of Being an In-Field Mathematics Teacher in Indigenous Secondary School Classrooms

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Queensland rural and remote schools have difficulty in attracting experienced, in-field mathematics teachers. Thus, when such teachers arrive, much is expected of them to increase the mathematics knowledge of students. This paper looks at one such teacher who, against the high expectations placed upon him as an in-field teacher, experienced challenges in teaching mathematics to underperforming Indigenous1 Australian students. The paper considers implications of in-field mathematics teachers in underperforming classrooms.

As the Australian Prime Minister, Julia Gillard, reiterated, one of the major policies of the Australian Government is to improve the qualifications of its teachers in order to enhance the quality of education for all students. According to Darling-Hammond (2010), teacher qualification is directly linked to the quality of teacher education certification programs, experience levels and strong subject content knowledge. With regard to mathematics, Ingersoll (1999) argued that the biggest problem facing secondary schools is the failure to ensure that all students are taught by "in-field teachers", i.e., qualified teachers who hold, as a minimum prerequisite, a college minor in mathematics.

Hawk, Coble, and Swanson (1985) found that in-field mathematics teachers were better at presenting material to students, while Golhaber and Brewer (2000) found that students taught by out-of-field teachers do less well compared to in-field teachers, concurring that classrooms must be staffed by high quality, well-trained teachers to ensure that all students are able to perform positively in mathematics and science.

In the Australian context, Thomas (2000) points to all the difficulties faced in rural and remote Australia to attract well qualified mathematics teachers as a reason for the further broadening urban and rural/remote economic gap. The Staff in Australia's School report found that rural and remote schools experience great difficulty in attracting and retaining in-field teachers, forcing principals to recruit out-of-field teachers for subjects such as mathematics (DEEWR, 2010).

Colonisation, continuous discrimination and past legislations refusing them their human rights have made the Indigenous community to be among the most marginalised groups in Australia (MacNaughton & Davis, 2001). Indigenous Australian students still remain very educationally disadvantaged (Matthews, Howard, & Perry, 2003), particularly in the field of mathematics (Matthews, Watego, Cooper, & Baturo, 2005). According to Philips, Lampert, and Healy (2004, p. 114), "Indigenous students who have constructed their cultural understanding about the world through their family may encounter different

[1] Indigenous refers to the Aboriginal and Torres Strait Islander peoples of Australia. Even though Indigenous is a homogenising term, that is, one people one culture, the meaning of the word in the context of this paper is the opposite. We recognise and respect that Indigenous people of Australia consists of many First Nations each with their own unique culture and histories.

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construction when they enter the classroom"; cultural capital that should be used to build their mathematical knowledge is absent in the traditional approach to mathematics instruction.

Tate (1995) defines traditional approach to mathematics instruction as typical mathematics pedagogy that

> … emphasizes whole-class instruction, with teachers describing a technique to solve a problem and students listening to the lecture. Students are then instructed to work alone on a set of textbook problems ... the purpose of this teacher directed model of instruction is for students to produce correct answers in a narrowly defined problem.

Edyburn (2006) argues against traditional forms of teaching mathematics, stating that physical and cognitive mathematics activities should replace the one-size-fits-all traditional instruction mode for students at risk of repeated failure.

Nichol and Robinson (2000) concur with Edyburn, arguing that non-Indigenous mathematics teachers should replace traditional "European methods" pedagogy of teacher-centred procedural learning with a more Indigenous-appropriate pedagogy involving holistic, imaginal, kinaesthetic, cooperative, contextual and person-oriented learning, as Indigenous students learn mathematics more through discovery and role-play rather than teacher-centred instruction. This would involve traditionalist mathematics teachers having to make pedagogical adjustments and epistemological shifts in moving away from a dualistic teaching approach with strategies that are more suited for student learning (Wilson & Goldenberg, 1998). Teachers must enhance the self-identity of Indigenous students and have high expectations of them to make them believe in their ability and competence as learners (Sarra, 2011).

The literature supports two findings. The first is that staffing all mathematics classrooms with in-field mathematics teachers is important to ensure quality of education for all students. The second is that there is a need for in-field teachers to move away from a one-size-fits-all approach to delivering mathematics lessons to underperforming Indigenous students as this form of instruction is not pedagogically compatible to their way of learning.

This paper presents a study exploring in-field teacher pedagogy in a current YuMi Deadly Centre (YDC) project called Accelerated Indigenous Mathematics (AIM). This project was designed to accelerate Years 8 students' mathematics understanding from a Year 3 level to a Year 10 level over a three year period. This would enable students to access Year 11 and Year 12 mathematics and improve their chances of employment. AIM is based on a program to teach mathematics called YuMi Deadly Maths (YDM).

To enable this mathematical acceleration, the AIM project partitions the Years 8-10 mathematics syllabus into topics and provides teachers with vertically sequenced resources or modules for each topic. These modules are (a) built around the big ideas associated with the topic; (b) connected and sequenced to efficiently teach the topic from Years 3 to 10; and (c) based on an active context-based pedagogy. This pedagogical framework, called RAMR (Reality-Abstraction-Mathematics-Reflection), advocates mathematics knowledge be developed from local realities, abstracted through body, hand and mind activities, consolidated as formal symbolic mathematics, and reflected back to local reality through application and extension. RAMR was designed specifically for teachers of underperforming students.

Description of Study

The AIM project involves nine rural and remote Queensland secondary schools, each with at least 30% of the student population being Indigenous. The project involves teachers and students in Years 8, 9 and 10, where the majority of students are underperforming and have a Year 3 mathematics level. For the purposes of this paper, a case study has been created around a single teacher in one of the nine schools. This teacher is representative of four in-field mathematics teachers in the AIM project (the project has 21 out-of-field mathematics teachers).

Participant

The teacher, named Doug (pseudonym) is an experienced in-field mathematics teacher in a school which this paper will call Hillside. He holds a Bachelor of Science in Mathematics (Honours) and a Graduate Diploma in Education (secondary mathematics), and has been teaching mathematics at Hillside for 6 years. He teaches the Year 10 advanced and the Year 10 foundation mathematics classes.

The AIM project is run in Doug's Year 10 foundation class. Like all AIM classes, this class has predominantly Indigenous students who are underperforming in mathematics. Though Doug is an experienced in-field mathematics teacher, this paper explores his initial teaching experiences using the RAMR pedagogical framework over a period of six months.

Doug took a lead role in involving AIM in Hillside. He did this so that Hillside students would have increased life chances. Doug believed that mathematics was a key requirement in securing employment opportunities that were available in the remote town. As he commented:

> Basically I got the school involved in it [AIM] because year after year our foundation kids, they're all getting E's and ... if we kept the set curriculum to them it wasn't benefitting the students whatsoever. Their confidence level is just going to keep decreasing over time.

He stated that one of the main goal of introducing AIM to the foundation class was because it "would help them [the students] in achieving that kind of thing [employment]".

Data sources

Three sources of data were available concerning Doug's classroom actions and pedagogical methodology.

1. General classroom observations were made by five researchers during scheduled school visits over a six month period. These observations were recorded on a template document, and included comments about the teacher's pedagogy, mathematical topic and impressions of student learning. There were three general observations available.
2. Specific classroom observations were made by the researchers using an observation checklist to count specific actions. There were three specific observations available.
3. Teacher interviews were conducted with Doug after each observed lesson to discuss and clarify information about the lesson and strategies used. These interviews lasted approximately 30 minutes. Doug was also interviewed at professional learning activities he participated in each term. There were five interviews available.

Results and Discussion

In this section we briefly describe the challenges faced by Doug in teaching the Year 10 foundation class. We compare Doug's teaching over time and discuss the pedagogical shifts he made. Finally, we draw implications for in-field mathematics teachers in schools with underperforming mathematics students.

Challenges

Doug found identifying appropriate pedagogies for his differing classes difficult. As he stated:

> I'd like to be able to walk into a classroom and just have the same style for every class. You can't do that. I've got the extension class, the top kids, and then I've got the foundation class where ... The extension kids are a bit up there, [you] cover the theory aspects, do some work examples with the students, then get them to do some independent practice, come back and have a look how they've gone. With the foundation class it's completely different.

Doug indicated that, prior to the AIM project, his teaching pedagogy to the foundation class consisted of (a) introducing the topic; (b) relating the topic to the real world; (c) giving examples; (d) students copying from the whiteboard; and (e) students trying independent work. There were no activities or hands-on materials involved in the learning. He commented that the students often did not remember what they had done in mathematics after a couple of weeks. This means that Doug's initial teaching ideas were consistent with a traditional approach to teaching mathematics.

Doug's initial attempts to abstract ideas using the RAMR pedagogical framework were limited (as can be seen in his initial RAMR teaching described as Time 1 in Table 1 below).

> I've gone from start to finish with each of the modules but I don't do all the activities that are suggested in there or anything like that. I probably don't do enough hands-on things with them. But I think I'll lose them if I'm trying to introduce a lot of hands-on things … we do a lot of sit-down practice work but we still try and have a discussion related to real-world. It's just the hand, mind, body thing is sometimes skipped over quite briefly.

This difficulty in teaching using the RAMR pedagogical framework at the beginning of the project was also attributed to the behaviour and attitude of the students in the Year 10 class. On this issue, Doug said:

> The students just weren't getting into it … and a few of the boys in there too they think they're big tough guys and "we're not going to be seen doing this kind of stuff" … it's just hard sometimes getting them involved in discussions especially, like give them a worksheet and they'll sit there quietly and work on that, but when it comes to talking about it, yeah …

However, Doug felt that the AIM project was providing for positive learning outcomes. As he said:

> ... realistically we shouldn't be doing the YDM with our Year 10's but I still think they are going to have shown a lot more improvement by doing this [YDM] than doing the National Curriculum … the majority of these kids would probably be going into pre-vocational maths next year, and I think we are giving them the skills that they need for that.

Comparison

Table 1 compares two of Doug's lessons. These lessons, designated as Time 1 and Time 2, were conducted approximately 6 months apart. The transition from Time 1 and Time 2 provides an indication of Doug's pedagogical shift away from the traditional mathematics teaching he was trained to do as an in-field mathematics teacher, towards a pedagogical framework specifically for underperforming students. This pedagogical shift indicated Doug's broadening teaching style that resulted in his underperforming students becoming engaged and actively participating in their lessons, thus enhancing the teaching and learning in his foundation class.

Table 1
Evidence of Doug's Pedagogical shift

Lesson Sequence	Time 1 Topic: Area →	Time 2 Topic: Fractions
Activity 1	Worksheets: Doug hands out a multiplication grid worksheet for students to fill in. Students disengaged.	Math mentals: Doug writes out a few multiplication questions on the board. Doug walks around the class, helping, praising and marking. Most students found exercises quite easy. Students settled and complied.
Activity 2	Area definition: Doug writes on whiteboard: "Area is a measure of coverage of a two-dimensional space or surface". Doug explains the math concepts behind the definition and questions students understanding of the definition. Students disengaged.	Fraction definition/Reality: Doug writes on whiteboard: "We can make a whole out of parts" and "We can make parts out of a whole". Doug encourages discussion on various sporting examples, encouraging students to relate their examples to fractions. Students interacted and were engaged in open discussion, actively contributed examples related to sports (NRL, gridiron and netball).
Activity 3	Reality: Students asked to provide examples of area. Doug provided most examples. Students complied but were predominantly passive.	Body activity 1: Doug asked six students to come up the front of class. Posed questions for students: "How many are boys? girls? have long hair?" Discussed mathematics language related to fractions with students. Students participate as models and observers enthusiastically.
Activity 4	Hand activity 1: Students made to sit in pairs and are given a pack of cards. They are asked to determine the number of cards needed to cover a desk. Students complied.	Hand activity 1: Doug hands out small rectangle (3x8cm) of paper. Students encouraged to make a variety of even parts. Several different folds are observed – vertical, horizontal, diagonal. All agreed that these folds were all halves. Students absorbed in activity.
Activity 5	Hand activity 2: Doug hands out A4 paper. Students asked to determine how many hands can cover the A4 paper. Students complied.	Hand activity 2: Doug hands out A4 paper with squares drawn on it, and scissors. Students encouraged to fold, cut and explore squares. Fold into four - language of quarters, fourths discussed. Some made further patterns in the folded paper. Students complied – some with great care and perfection. Several different pattern versions

		were developed.
Activity 6	Whiteboard: Doug draws shapes on whiteboard, asks volunteers to come and colour into shapes. Explains that shapes with colour have Area. Students reluctant.	Hand activity 3: Doug hands out 12 counters to each student. Encourages students to develop groups of 3 – language of thirds, sixths, equal groups developed. Students are engaged and complete the task.
Activity 7	Hand activity 3: Doug hands out graph paper and drawing compass. Students draw a circle to determine the number of boxes within the circle. Students reluctant.	Mind activity 1: Doug gets students to close their eyes and imagine counters. Doug proceeds to verbalise various grouping sequences so that students visualise and determine fractions. Students complied, and demonstrate ability to visualise fractions.
Activity 8	Students decided to play cards for remainder of the lesson.	Reflection: "What have you learned today?" Students quoted statements on the board, then the terms 'equal parts', 'quarters' etc. Students complied.

Both Time 1 and Time 2 incorporate aspects of the RAMR pedagogical framework. The Area lesson (Time 1) details Doug's evolving development while the Fractions lesson (Time 2) details a more advanced implementation of a RAMR-based lesson.

As previously indicated, the analysis of the classroom observations detailed in Table 1, together with responses received from interviews identified three main pedagogical shifts carried out by Doug to better engage the foundation class in mathematics learning.

Pedagogical shift No. 1: Implementing the RAMR pedagogical framework. The transition from Time 1 to Time 2 shows how Doug's implementation of reality, body-hand-mind and reflection has evolved successfully. While Time 1 did have reality and hand activities, there was still evidence of the traditional mathematics teacher in Doug's emphasis of basing the lesson on the definition of Area as the driving force behind the activities, and worksheet-type activities where students were to create meaning based on the definition and formulae of Area. Time 2 demonstrated a well executed lesson framed around RAMR, with reality being based on simple definitions, student-driven reality examples, well executed body activities, concluded with different hand activities relating to Fractions. Observations during the Fractions lesson showed that mathematics language was developed and strengthened throughout the body-hand activities.

Pedagogical shift No. 2: Short-simple activities. While activities in the Area lesson (Time 1) were observed to be more time-liberal 'form a group, do the activity and see how you go', the activities in the Fractions lesson (Time 2) were well prepared and sufficiently paced to keep students actively learning and moving between activities to keep engagement consistent throughout the lesson. As Doug indicates "I'm slowly starting to realise that these kids, they just need simple 5 to 10 minute tasks, then move on".

Pedagogical shift No. 3: Breaking down the mathematics. The activities in the Fractions lesson (Time 2) clearly had the mathematics related to the activities, and both teacher and students participated as equals in determining the language and meaning. Doug related the reality to sports: engaging and prompting the students to provide examples such as NRL ("half-time", "two-halves"), "quarter-back" (gridiron) and a discussion around netball. Doug's knowledge of netball was enhanced as he learnt from the students that a goal-shooter can only access one-third of the court while a goal-attack has access to two-thirds of the court. Doug later pointed out: "The students got into this example, even though they weren't interested in netball".

The body activity (students at front of class) introduced the concept of 'out of', i.e., 4 out of 6 persons at the front of class are boys, 3 out of 6 have long hair, etc. In hand activity 1, a student made a connection between his 3x8cm rectangle and the netball court example from the reality activity, while another student asked "Sir, if you had a whole, could you call it one out of one?" Doug expressed satisfaction that "students understood the concept. Lots of students were solving fractions in a number of different ways, which was good".

Summary and Implications

The findings show the complexities faced by a traditional in-field mathematics teacher in having to undergo pedagogical shifts in order to effectively teach a variety of student ability levels. The traditional mathematics pedagogy that is perceived to be effective for preparing students for post-compulsory school opportunities has been shown to be an ineffective strategy in classrooms where students have had a history of experiencing repeated failure.

Doug is an experienced in-field mathematics teacher, very similar to three other teachers in the AIM project. That the AIM project has only four in-field mathematics teachers and twenty-one out-of-field mathematics teachers, illustrates the difficulty that Queensland has in providing in-field mathematics teachers in rural and remote schools. There is substantial research that claims that classrooms need to be staffed by well trained teachers to ensure that all students are able to perform positively in mathematics (Golhaber & Brewer, 2000).

This paper has shown that being a high quality well trained mathematics teacher may not be enough to ensure mathematical learning in all students. Edyburn (2006) concurred with Nichol and Robinson (2000) that traditional pedagogies need to be replaced with pedagogies related to discovery and role-play in classrooms of underperforming students. Doug realized that his underperforming students required something other than traditional mathematics pedagogy. Doug needed to explore himself as a teacher and undergo a series of pedagogical shifts in order to engage his students. It appeared Doug's preferred teaching style was teacher-centred, but to enhance the learning of his foundation class, lessons needed to become student-centred.

In the drive by the Australian Federal Government (DEEWR, 2010) to ensure all schools are staffed by in-field mathematics teachers, there needs to be an equal drive that recognizes that in-field mathematics teachers need to be pedagogically flexible and able to teach all student ability levels. This is essential to ensure that all no student is left behind, and to closing the gap between Indigenous and non-Indigenous students.

Two key implications for mathematics teacher education arise from the study. Firstly, pre-service mathematics teachers need course components that relate to the teaching of underachieving students. This is as equally important as developing their skills for rigorous mathematics teaching. Secondly, in-service teacher education needs to be available over extended time periods, and not simply as a 'snapshot' offering. Pedagogical shifts develop over time.

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