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A secondary mathematics teacher's perceptions of her initial attempts at utilising whiteboarding in her classes

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Abstract
Excellent mathematics teachers establish learning environments that encourage students to actively engage with mathematics and foster co-operative and collaborative learning. Whiteboarding, using an erasable surface on which to work and share ideas, has been shown to increase student engagement, collaboration, and higher-order thinking. We report on one teacher's experiences as she introduces whiteboarding into her secondary mathematics classroom. The teacher reports increased student confidence and collaboration and we see a shift in her focus from concerns about classroom management, to a passionate recommendation to use whiteboarding in mathematics instruction.

Keywords
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Excellent mathematics teachers establish learning environments which encourage students to actively engage with mathematics and foster co-operative and collaborative learning. Whiteboarding, using an erasable surface on which to work and share ideas, has been shown to increase student engagement, collaboration and higher order thinking. We report on one teacher's experiences as she introduces whiteboarding, in a classroom with whiteboards mounted on all walls, into her secondary mathematics classroom. The teacher reports increased student confidence and collaboration and we see a shift in her focus from concerns about classroom management, to a passionate recommendation to use whiteboarding in mathematics instruction.

Introduction

The AAMT Standards (AAMT, 2006), in defining excellence in mathematics teachers' professional practice, maintain that excellent mathematics teachers maximise students' learning opportunities by: actively engaging students in their learning; establishing learning environments which encourage students to engage with mathematics; fostering co-operative and collaborative learning; expecting and encouraging students to "have a go"; encouraging high quality verbal and written communication; monitoring students' practice to plan for future learning experiences, and to map and report on students' progress. These teachers utilise classroom organisation and teaching strategies which best meet students' learning needs. This paper reports on one teacher's experiences as she introduces whiteboarding into her mathematics classrooms, in an effort to inspire her students to "embrace maths in terms of their future goals and make maths as exciting as possible for them" (Gail, Individual Interview).

Whiteboards and Whiteboarding

The term *whiteboarding* has been in use since the 1990s, and has been defined as "the action or process of using a whiteboard, especially as a means of collaborating with others" (Oxford University Press, 2016). While within educational settings whiteboards can be used for students to display their work, whiteboarding is essentially an active learning process involving students communicating, taking risks, making mistakes, sharing, modifying and evaluating their own and each other's ideas (Wenning, 2005).

The whiteboards used for whiteboarding can be virtual or real, electronic or not, hand held, mobile on wheels or easels, mounted on a table top or a wall (they may be the table top or wall) and range in size from very small to the size of a classroom wall. Whiteboarding, in fact, does not require a whiteboard at all. Any easily erasable, easy to write on surface will do; blackboards certainly fit the bill, as do windows, or electrostatic plastic film. The essential features of whiteboards are the readily shared space they provide for recording ideas, their ease of use in communicating these ideas, and the flexibility they provide for writing, erasing and modifying responses.

The literature describes the utilisation of whiteboards, in various forms, across a variety of educational settings and disciplines to support collaborative learning, to support the development of higher order thinking, to improve the quality of classroom discourse and to provide the teacher with insights into students' thinking.

Mini whiteboards (used in primary and secondary schools across a range of disciplines), while not generally associated with collaborative whiteboarding, are useful for increasing classroom interactivity (Beauchamp & Kennewell, 2008), engaging all students in classroom discussions and enabling teachers to gain immediate, simultaneous feedback from all students and insights into their understanding (Wiliam & Leahy, 2015; Swan, 2006). Their appeal to students involves their non-permanence, which appears to encourage them to take learning risks and to engage quickly with the learning task, understanding that they can readily modify their responses with no lasting record of their work (Swan, 2006).

Medium-sized hand-held whiteboards have been used by students working collaboratively in small groups to record their solutions, findings or ideas, which are subsequently presented to, and discussed with, their peers (Wells, Hestenes & Swackhamer, 1995; Wenning, 2005; MacDuff, 2011). Wenning (2005) claims that this kind of whiteboarding affords improved classroom discourse through making student thinking visible, enhancing student cooperation, motivating students to become active in their own education; improves communication skills, increases student participation and enhances student learning (whiteboardsUSA, n.d.). West, Sullivan and Kirchner (2016) found group whiteboarding on medium hand-held whiteboards enabled elementary science classes to jointly generate, share, synthesise and build on their ideas, while building their literacy through improved classroom discourse. Henry, Henry and Riddoch (2006) appreciated the flexibility the whiteboards provided for recording, modifying and discarding students' ideas and the easy access students had to each other's thinking, which promoted whole class discussion and understanding. MacIsaac (2000) found this method of whiteboarding valuable for actively involving students in large first year physics lectures in workshop-type activities. His students found whiteboarding increased their motivation, concentration and interest, enabled active participation in lectures and promoted deep thinking. They found that whiteboards facilitated the easy recording and sharing of solutions, assisted them in visualising concepts and afforded them opportunities to critically evaluate and support each other's learning.

Board rooms

Large, wall mounted, or mobile whiteboards are usually located centrally at the front of classrooms and are often the focal point for the delivery of teachers' notes, or as a teaching space for teacher-led demonstrations, discussions or explanations. However, de-fronting the mathematics classroom by fixing large whiteboards on all available vertical surfaces—creating a *board room*—for the use of students in doing mathematics, is being utilised in several educational settings with remarkable benefits.

The 360 Degree Math program, created by science teacher Sean Kavanaugh, is aimed at improving students' mathematics scores and engagement with mathematics (Antoniades, 2013). As Kavanaugh describes it (Antoniades, 2013), the program gets students out of their seats and working on wall-mounted whiteboards, students' thinking becomes visible, the teacher becomes the audience and the students become the performers. Although no research based evidence has been published, Kavanaugh reports that students' engagement

with mathematics improved dramatically, as did the school's performance in School District mathematics assessments (Antoniades, 2013).

Liljedahl (2016) utilises board rooms as part of a collection of classroom practices aimed at bypassing normative classroom practices which inhibit students' development of problem solving skills and mathematical thinking. He found that students working on whiteboards were more eager to start, evidenced more discussion, participation and persistence, and recorded more of their exploratory approaches to the problem, than on non-erasable surfaces. Wall mounted whiteboards were the most effective in nearly all of these measures and students were more mobile in sharing their knowledge and seeking support when working on vertical boards.

Seaton, King and Sandison (2014) describe *board tutorials*, classes where university students complete their mathematics problems at boards mounted on walls around the room instead of in their notebooks. This practice was introduced at our university 25 years ago. While the outcomes of this approach have never been researched, it is considered a very successful innovation by tutoring staff. "What a difference! Where tutorials had once been quiet, passive affairs, they were now full of animated, engaged learners and teachers…students interacted with the subject material, collaborated with other students, and interacted with the tutor" (p. 106). Students are no longer anonymous and cannot hide their lack of engagement or understanding as tutors can readily see students' misconceptions and deal with them.

Introducing this approach into secondary school mathematics classes has been of interest to us for the past three years. A pilot study comparing high school students' engagement in a class held in a board room and a class held in a desk room (Sandison, Forrester & Denny, 2015) found behavioural engagement to be considerably higher in the board room. A teacher interview and student survey indicated that both the teacher and students were very positive, reinforcing the benefits already mentioned.

Having identified the benefits of using whiteboards in several educational settings we are interested in assisting teachers in developing their classroom practices into board rooms to support the engagement and learning outcomes of their students. Therefore, we commenced this study with this research question: What are the perspectives of teachers introducing board rooms into their secondary mathematics classrooms?

Methodology:

The qualitative research reported in this paper is informed by phenomenology, which seeks to understand an experience from the perspective of the participants (Kervin, Vialle, Howard, Herrington & Okely, 2015). The study seeks to investigate the lived experiences of a group of teachers introducing board rooms into their secondary mathematics classes.

Data were collected through individual interviews with each participant to gain background information, followed by four semi-structured focus group interviews with four participants undertaken over a period of six months. Three focus group interviews were undertaken in the fourth term of the school year, the final interview was conducted at the end of the first term the following year. Between the third and fourth interview professional development involving the development of *thinking classrooms* (Liljedahl, 2016) was provided to participants.

Focus group interviews were considered advantageous for this study as they provide interaction among participants and can yield extensive and rich data (Creswell, 2015). The first focus group interview was undertaken prior to, or immediately following, the installation of the board rooms, the second two weeks later, the third a further two weeks

later and the fourth nearly five months later. Focus group interviews were audiotaped and transcribed and thematic analysis conducted. This paper presents the findings in relationship to one participant teacher, Gail[1].

Participant

At the commencement of this project Gail had been teaching secondary mathematics for seven years and was teaching five classes: a low ability Year 7; a high ability Year 9; a moderate to high ability Year 10; a low to moderate ability Year 11 General Mathematics[2] and; a low to moderate ability Year 12 General Mathematics 2[3].

Gail is very keen to take on leadership roles within her school and mathematics education community. Gail is an extremely well prepared and organised teacher whose mathematics classes are characterised by control; focusing the first term of every year establishing and maintaining rules, routines and expectations. Gail believes her role as a teacher is to help students understand the importance of mathematics for their future, to inspire them to embrace mathematics and be excited by it. She aims to show students the relevance of what they were learning, often connecting mathematics with other Key Learning Areas. Gail utilised group work, encouraged collaborative learning and aimed to build confidence in her students.

As an alumni of our university, Gail previously experienced learning in the board rooms as a student and, later as a tutor. Gail's experiences in the board rooms were very positive, indeed, Gail loved the "success behind it" (Individual Interview).

Results

Before whiteboard installation

Gail entered the study concerned that the number of students taking mathematics was dropping. She identified the need to try new ways of teaching to motivate and engage students. "I'm all for trying something new, particularly with the low ability kids and getting them engaged and excited about mathematics" (Focus Group 1 (FG1)). From her experiences as a student and tutor, Gail was enthusiastic about using board rooms at school, believing it would allow students to lead the way in their learning, with her role being a guide for them on their "self-discovery journey" (FG1). Her goal was to build students' confidence in mathematics, "breaking down those barriers that the kids have … of maths... If I can get every kid from the bottom to the top to say, 'I can give something a go in maths', I've done my job" (FG1).

Gail had firmly established class expectations and structure, which differed from class to class according to Year level and ability. Students in all classes were seated in rows to enable Gail to give direct instruction and monitor attentiveness. Typically, Gail's lessons involved a computer presentation, followed by checking homework and practice activities. In providing direct instruction, Gail looked to make the mathematics relevant and to ensure student understanding. She utilised group work to encourage peer learning.

Prior to installing the whiteboards Gail was excited by the possibilities the board room would provide to change classroom practice, humorously saying "let's throw out the

[1] A pseudonym

[2] General Mathematics is the lowest level of mathematics for Year 11.

[3] General Mathematics 2 is the lowest level of mathematics examined at the NSW HSC.

desks" (FG1). However, she also had reservations regarding classroom and behaviour management. She was concerned about how she would control students' behaviour while at the boards, how she would avoid students writing or drawing inappropriate words or pictures on the boards and how to accommodate the 28 students in her Year 9 class.

Gail's main concern – classroom organisation and management

Despite her reservations, Gail used the whiteboards every day for practice activities after a time of direct instruction and demonstration. Gail attempted to de-front the room by rearranging the desks into groups and standing at a different board each lesson to deliver her initial ten-minute explanation/demonstration of the topic. However, after a few weeks, Gail found that grouping tables was not efficient for her direct instruction time, as she wanted to use the fixed mounted projector. Gail could see no way around this, so rearranged the tables into a U shape, reluctantly re-establishing a front.

Initial classroom and behaviour management concerns led Gail to introduce several behaviour and classroom management measures. These included: the establishment of board rules and associated consequences; controlling and monitoring movement to and from the boards; introducing a "texta licence", which students earned by demonstrating a pre-determined level of understanding, and carrying with it a sense of "privilege" to be working at the boards; students writing their names at the top of their boards to ensure they took responsibility for any writing or drawing; and having half of the large Year 9 class working on the boards at one time, while the other half worked at their desks.

Gail found her initial concerns for classroom and behaviour management unfounded. Having established effective classroom management previously, the transition to board work seemed to flow easily and, in fact, when students were working at the boards she could monitor their behaviour more readily than when they were working at desks. As Gail observed, "you'd be foolish to be off task because I can see what you're doing" (FG1).

The main behavioural change Gail noticed as a result of board work was an increase in classroom discourse and resulting increased classroom noise. While this was notable, it did not concern Gail, commenting: "You can't go in there and expect them to quietly just work on the board." In fact Gail found the increased conversations a sign that students were engaged with the mathematics and working collaboratively: "So as long as they're talking about "$yx + 3 = \ldots 10$" and how they got to x, I don't care that they're talking" (FG3).

Gail had often provided opportunities for group work at desks and so she was keen to exploit the opportunities the whiteboards provided for collaboration and peer support. She regularly encouraged her students: "if you're stuck, look over your shoulder and see what others are doing" (FG1). In the Year 9 class where only half the class worked on the boards at any time, Gail urged those at the desks to look at the work on the boards, seeing this as "peer demonstration".

Gail's approach to lesson preparation and delivery

Prior to installing the board room Gail decided to utilise the whiteboards all the time, in her words "I decided to throw myself into the deep end and hope that I could swim" (FG1). However, after installation Gail lacked confidence in how to use them, commenting that she had to force herself, while trialling how to use them. Gail's initial teaching approach was to simply prepare as she would for her normal lesson but ask students to do all their practice work on the boards instead of in their books. This strategy worked well for Gail as

it was relatively easy to implement and required changes to classroom management rather than a major shift in her teaching.

Gail sought regular, anonymous feedback from her students and found students were so keen to work at the boards, that she began to consider alternative strategies to get students onto the whiteboards immediately as they entered the classroom, rather than after her normal introductory session. She discussed a few possible strategies at the second focus group and thought she might try pre-printing lesson notes, handing them out without giving an explanation/demonstration time and "let [students] figure it out" (FG2). However, Gail did not report trialling this. After four weeks, while she was convinced that the board room provided the best environment for students to complete their practice activities, she still felt constrained by the need she saw for students to take notes "so they can see a model…of what they're expected to do…that way when they go home they've got something they can flick through, as their summary when they are going to study as well" (FG3).

In the second meeting Gail discussed trialling assessment on the boards and attended the next focus group meeting excited to share her successful first attempts giving a standardised algebra test with differing numbers and pronumerals. While she required students work silently, she encouraged them to look around the room to get ideas and felt this assessment compared favourably to regular pen and paper tests.

Five months on, Gail had been promoted to a different school which had a board room as a common teaching space and introduced whiteboarding to her students and mathematics staff. In Week 5 of Term 1 she attended the *Thinking Classrooms* Professional Development session and started to incorporate problem solving tasks into her lessons. Her practice was continuing to develop and at the end of Term 1 (FG4) she commented:

> I'm finding from this experience [focus group discussions] and talking to Peter [Liljedahl] as well, I love, like, riddles and puzzles and things like that and I'm finding I'm searching more and more for them and the more I give it to the kids…as a reward at the end, they kind of get their work done to say, "well, where's the riddle?". I started to research open ended riddle stuff to match what I'm doing. So when I did finance with my…Year 12 class, and Year 11 classes, I put the tax man [problem] in there, 'coz it's finances. And then…when I did a bit of algebra, I put the Einstein's riddle for them to try and solve. So those sort of problem solving are now starting to creep more and more into my teaching as well.

Gail's perceptions of her students' responses

Early in the study, Gail reported differing initial reactions to board room lessons from different classes. Her Year 12 "absolutely love[d] it in there" (FG1), while her Year 9 students were reluctant; "You can't be serious, you can't expect us to do this!" (FG2). However, by the end of the lesson, they appeared to be enjoying themselves and later when asked to evaluate the board lessons most spoke positively, saying, "we're getting more out of it" (FG2).

Over the next few weeks, Gail felt she was building confidence in all her students, they were enthusiastic to do mathematics on the boards and were enjoying their mathematics experiences. While she became concerned that some students were not paying adequate attention to her introductory presentations/explanations, because they were so keen to get up to work at the boards, she realised that they were helping each other and collaborating at the boards and not missing out.

Gail was encouraged and surprised by her students' responses:

> I think my biggest surprise…going into this project initially, I thought yep, top kids are going to benefit from this, bottom kids not so much and I found that was certainly reverse to the truth. The

> bottom kids are getting in there again, having a go, whereas the top kids I've had to split—because they're such big classes—half-half [so they do not get as much time on the boards] but overall the student feedback was very positive. (FG3)

Gail's conclusion – Throw yourself out there…see what works!

Following Gail's promotion to a new school where she no longer had whiteboards in her own room but had to book a common space, her enthusiasm for whiteboarding continued to grow. Gail used the board room as much as possible (often sending a student down mid-class to check if it was free), but found for her smaller Year 12 classes she had enough space on her own whiteboard. This loss of her own board room led Gail to comment, "having the opportunity to be in the deep end and then ripped out of the deep end and put into the shallow end, I want my deep end I would have stayed there" (FG4).

Gail is now passionate about using board rooms in the instruction of mathematics—she no longer talks of "texta licences", nor is she concerned about classroom management or behaviour issues. She has experienced success with students of all abilities and this now drives her to share practice with others and encourage the use of board rooms. She encourages others to trial whiteboarding, to 'throw yourself out there…and see what works', to persevere for at least six weeks to get a sense of best use and benefits.

> I feel if this is the direction that we are going to go as a mathematical society, this is bigger than just … us who are a couple of teachers. We need to get the deputies and principals on board and when we throw teachers in with the whiteboards and start putting them into the schools they will have no choice but to start using them and when they have no choice, that's when they start to develop themselves and it's that whole regenerating interest in what you're doing (FG4).

Discussion, Conclusions and Implications:

While Gail's initial conversations focused on classroom management, the benefits of teaching in a board room and whiteboarding, as highlighted in the literature, were emerging from her reflections. The board room made students' behaviours and thinking visible (Liljedahl, 2016; Seaton, et al., 2014), enabling Gail to easily monitor her students' behaviour and mathematical thinking. In line with the literature and in keeping with excellent pedagogy as defined by AAMT Standards (2006), active participation, classroom engagement, discourse and collaboration immediately increased in all of Gail's classes, regardless of Year or ability level (Liljedahl, 2016; Sandison et al. 2015, Wenning, 2005). The ease of student mobility (Liljedahl, 2016), the opportunities the boards afforded to access each other's thinking, explore ideas, and easily modify or discard them (Liljedahl, 2016; Swan, 2006; Wenning, 2005; Wiliam & Leahy, 2015) seems to naturally motivate students and induce on-task talking, behaviour and collaboration (Sandison et al., 2015).

Although Gail's enthusiasm to "dive in" to whiteboarding was palpable, her initial concerns and efforts were focused on classroom management. An area of strength in her classroom practice, it was interesting that her determination to maintain classroom control dominated her initial preparation. The literature on whiteboarding and the use of board rooms does not discuss this as a constraint or challenge, and it would be worthwhile investigating if this is a common issue for teachers considering or implementing whiteboarding into their classroom practices.

Knowing where to start in board room teaching was not clear to Gail, despite being a thoughtful, motivated and well prepared teacher. Her determination to trial whiteboarding led her to continue with her normal practice while simply switching from book work to board work for practice activities. This was a successful strategy for Gail. However, once

she was confident in her ability to manage her students' behaviour, Gail began to experiment with her pedagogical practices, responding to students' feedback, needs and behaviours, her professional discussions in the focus group meetings and the *Thinking Classrooms* professional development. Gail explored whiteboard assessments and began to introduce more engaging, non-routine problem solving riddles and puzzles into her lessons, trying to link them meaningfully with syllabus-based content. The identification or development of non-routine problems linked to the curriculum content can be time consuming and difficult. Gail benefitted from the professional development provided by the focus group interviews and offered in this research. In exploring the experiences of teachers in their early efforts at whiteboarding, their approaches, successes, challenges and obstacles we are looking to gain a clearer picture of the types of support needed to ensure success.

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