Improving Student Motivation and Engagement in Mathematics Through One-to-one Interactions

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The phenomenon of the 'middle-years dip' in mathematics engagement and achievement has been a cause of concern for over a decade. This paper presents an example of one upper-primary classroom identified as having higher than average levels of student engagement, with the purpose of documenting specific teaching strategies that align with known key elements of motivation and engagement. Drawing on evidence from teacher interviews, observation notes and lesson video with recorded dialogue, we argue that particular types of one-to-one interactions between teacher and student can have a powerful influence on student engagement.

Introduction

In Australia, the under-participation of middle-years (late primary - early secondary) students in mathematics has been widely reported (Sullivan & McDonough, 2007). For example, national reporting of numeracy benchmarks (MCEETYA, 2005) highlight the drop in numeracy results experienced by New South Wales students during the vital transition period of primary to secondary school (years 5/6 to 7/8). This decline has resulted in fewer students continuing with further mathematics study in senior school and beyond, causing a shortage of suitable employees for mathematics-related occupations (DEEWR, 2008). The dual issues of under-participation and under-achievement in mathematics are often described in terms of declining motivation and engagement, and a substantial body of research has found that motivation and engagement are positively associated with student academic achievement (Martin, 2007; Stipek, Salmon, Givvin, Kazemi, Saxe, & MacGyvers, 1998). However, this relationship is not necessarily causal, at least in the short-term. High levels of motivation and engagement do not ensure high levels of achievement and vice versa. There are many mathematically capable students who opt out of mathematics study as soon as it becomes an option. Yet there has been much difficulty in clearly identifying the actual causes of declining motivation and disengagement during this crucial time for students. A number of factors are at play, including social influences, curriculum, pedagogy and personal changes in students relating to early adolescence. In recent years researchers have achieved two significant advances towards a solution to the problem: a) coherent models that account for the multifaceted nature of engagement, drawing together the various definitions and theories; and b) reliable instruments for measuring the facets of engagement exhibited by individual students and monitoring changes over time (Martin, 2007, 2010).

Educators and researchers have long believed that the teacher is the key to determining the quality of learning in a classroom, but when looking for reasons behind the decline of

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engagement and performance in middle-years mathematics, educators have tended to be distracted by other factors such as the physical and social development of adolescents and societal influences. However, recent research utilising a multi-faceted model of engagement and an associated measurement instrument has identified the fact that it is not necessarily transition and personal development that causes engagement declines; rather, student, home, classroom, and school factors explain the bulk of such variance – and that amongst these factors, it is the variation in individual students that is the strongest (Martin, Anderson, Bobis, Way, & Vellar, 2012). This means that, potentially, the teacher can overcome the broader influences of developmental change, school and home by focusing on specific characteristics of individual students (Martin, Way, Bobis, & Anderson, 2015). The 'middle-years dip' in mathematics is not inevitable. The research reported in this paper extends this important finding by identifying specific strategies that one teacher uses to promote higher levels of student engagement in mathematics learning via her interactions with individual students.

Motivation and Engagement

'Engagement' is now generally accepted to be a multi-faceted construct that can be broadly described as three (interrelated) categories of engagement – behavioural, emotional and cognitive (Fredricks, Blumenfeld, & Paris, 2004). In general, 'motivation' can be described as a set of interrelated beliefs and emotions that influence and direct behaviour (Wentzel, 1999). However there have been numerous theories developed to explain the processes at work in both engagement and motivation - including attribution, expectancy-value, goal theory, self-determination, self-efficacy, and self-worth motivation theory. Such fragmentation has highlighted the need for a model that encompasses the strengths of the various theories and enables practitioners, such as teachers, to employ a framework that is easily translated into teaching strategies and communicated to students. The research reported here makes use of such a model, depicted diagrammatically as the student Motivation and Engagement Wheel (Figure 1); and represented in the associated Motivation and Engagement Scale, in the form of a validated questionnaire (Martin, 2007).

The student Motivation and Engagement Wheel (Hereafter referred to as 'M&E Wheel') identifies the thoughts, emotions and behaviours that enhance or impede motivation and engagement (Martin, 2007, 2010). The *Adaptive Cognition* section reflects the thoughts that boost motivation. These thoughts consist of *self-belief* (the student's belief and confidence in their ability to understand their schoolwork); *mastery orientation* (a learning focus, whereby the student is interested in developing new skills and understanding); and *valuing school* (the student's belief that the learning is useful and relevant). The *Adaptive Behaviours* section identifies behaviours that enhance motivation and is comprised of *persistence* (how the student perseveres with schoolwork); *planning* (the student's planning and monitoring of their progress); and *task management* (the student's study organisation, including time management). Adoption of these thoughts and behaviours results in increased motivation and engagement (Martin, 2007, 2010).

Thoughts and behaviours that reduce motivation and engagement are reflected in the *Impeding/Maladaptive Cognitions* and *Maladaptive Behaviour* dimensions (Martin, 2007, 2010). Negative thoughts include *anxiety* (feeling nervous about school work); *failure avoidance* (the student feels that if they do not complete their schoolwork they will be seen as a failure); and *uncertain control* (students feel unsure of how to do well and believe that their success is out of their control). Behaviours that hinder motivation and engagement are: *self-handicapping* (adoption of strategies that reduce chances of success, such as procrastination); and *disengagement* (giving up, withdrawing or accepting failure). For a fuller description of the M&E Wheel in relation to mathematics see Bobis, Anderson, Martin and Way (2011).

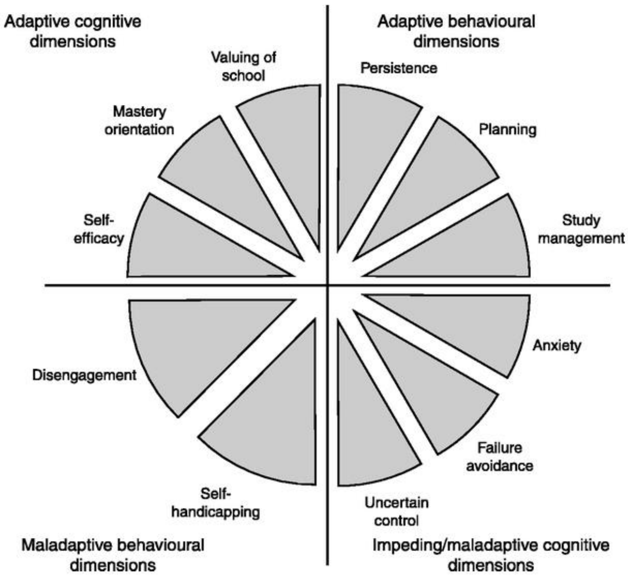

Figure 1. Motivation and Engagement Wheel (reproduced with permission from Lifelong Achievement Group (www.lifelongachievement.com) and Martin, 2010, p. 9.

Teacher-Student Interactions

As previously mentioned, the relationship that exists between student engagement and student achievement is not necessarily causal. This signifies that there may be highly motivated students demonstrating low levels of achievement and, conversely, students with low (or falling) levels of motivation achieving relatively highly. This situation suggests that, although teacher practices that enhance student engagement and those that improve student learning-outcomes may overlap, these practices are not necessarily indistinguishable. There is a growing body of research that asserts that positive interpersonal relationships between the teacher and student support both engagement and academic performance (E.g., Attard, 2013; Clarke et.al, 2002). The complementary nature of the pedagogy to support engagement and pedagogy to support learning is not surprising considering one of the three inter-related types of engagement is ‘cognitive’ engagement, that focuses on learning. For example, Hackenberg (2010) proposes that to build teacher-student relationships aimed at mathematical learning, teachers must assess and monitor the student’s mathematical thinking, attempt to view the mathematics from the student’s perspective and interpret the student’s feelings about the mathematics. She also highlights the reciprocal nature of these relations, in that the teacher needs to receive some positive responses or feedback from the students in order to build the relationship. If these relationships are built successfully, the student is likely to learn the mathematical content and, in turn, develop increased self-belief in their mathematical ability (Hackenberg, 2010). Increased self-belief and a focus on learning the mathematics content (mastery orientation) are positively associated with motivation and engagement (Martin, 2010).

In particular, one-to-one interactions between teacher and student may have significant value in building supportive relationships (Frymier & Houser, 2000), and promoting mathematics learning (Cheeseman, 2009). However, the specific nature of such individual interactions in mathematics classrooms remains under-researched, and little attention appears to be given to the specifics of these pedagogical relationships in teacher education and professional development (Sullivan, Mousley, & Zevenbergen, 2006).

Theoretical Perspective of the Study

The relevance of studying teacher-student interactions is supported by theories of social constructivism, which focus on the learner's construction of knowledge in a social context, including support from the teacher (Cobb, 1994). More specifically, the theory of *symbolic interactionism* has been used in mathematics education to explain how meaning is made through social interactions (Yackel & Cobb, 1996). Symbolic interactionism asserts that mathematical meaning is negotiated, and the theory can be used to explain how the teacher and students co-construct the social norms of the classroom related specifically to mathematics. These norms maintain established patterns of classroom interaction, regulate mathematical argumentation and influence learning opportunities for both the students and teacher (Yackel & Cobb, 1996). It follows that an appropriate approach to investigating teacher-student interactions is to closely observe particular established classrooms, with the understanding that each may be a unique situation.

Methods

This study's focus is expressed by the following research question: What interactions with students does one teacher use in a mathematics lesson, and how do these interactions relate to aspects of motivation and engagement?

Participants

This study was nested within a large mixed-methods project designed to research the phenomenon of the 'middle-years dip' in mathematics engagement and achievement. Longitudinal data from the Motivation and Engagement Scale questionnaire (Martin, 2007) identified six primary and secondary classrooms (from 200) in which student motivation and engagement was found at higher than expected levels, to become case studies. The set of six cases is currently undergoing systematic cross-case analysis, but data from one of the primary classrooms was analysed immediately via an Honours research project and is the subject of this report.

The Year 6 class was in a co-educational Catholic primary school in a large metropolitan area, with students from a wide range of cultural and socioeconomic backgrounds. The teacher, 'Kate', was female, aged 41-50, with over 21 years teaching experience and over seven years experience teaching upper primary. Kate collaborated with another Year 6 teacher in a team-teaching approach with 57 students. The two teachers planned the mathematics program together, with a unique structure that consisted of three groupings of students per lesson: *workshop group* (students having the most difficulty), *core group* (students needing consolidation and practice) and *enrichment group* (high achieving students needing further challenge). These groups were fluid, in that students chose which group to attend each lesson, based on their self-assessed ability after completing the whole-class, introductory task. In the observed lesson on fractions, Kate worked exclusively with the workshop group – the under-achieving students, who she referred to as "the little ones". It is this subgroup of students and this phase of the whole lesson that defined the boundaries of this particular case study (Yin, 2009).

Data Collection and Analysis

Kate's work with her group was video-audio recorded and field-notes were taken by the researcher. Semi-structured interviews were conducted with the teacher before and after the lesson to discuss student engagement, learning and pedagogy, with some specific questions about teacher-student interactions. For example, "Have you planned one-to-one interactions? If so, what kind of interactions? With whom?" and, "When you were walking around talking to the individual students, what kind of strategies did you use?"

Data analysis took place in three phases. The first phase used inductive (open-ended) analysis to identify and document all instances of interactions between Kate and her students through repeated viewings of the videoed lessons. These instances were then grouped into themes, then tentatively categorised according to commonalities. The second phase also used an inductive approach to identify themes in the interview transcripts and field notes. These themes were then applied in refining the researcher's interpretation of the themes and categories of teacher practice derived from lesson-video. The final phase involved looking for alignment between the identified teacher strategies and the elements of the M&E Wheel (Figure 1)

Findings

Kate declared that her major aim when working with the 'underachievers' group was to promote active participation and student understanding, saying, "the whole reason is getting them to understand why, rather than being told 'this is why'". To achieve this she deliberately interacted with individual students throughout the majority of the lesson, because "I know that I get better results with the one-on-one". Most of these interactions took place privately rather than in front of the group. Kate explained,

> For the little ones who couldn't answer, they wouldn't answer so why would you if you have got the other children there? ...You won't play tennis against someone who is McEnroe if you can't hit the ball. Why would you do that with maths?

Analysis of the interviews and the lesson video, interviews and field notes revealed three major categories of practice: pedagogical practices, practices contributing to a quality learning environment, and nonverbal practices - with strong alignment between the three data sources. Although there are some interrelationships between these categories, Kate's own explanations of what she was doing and why, provided further differentiation. Direct quotations from the teacher (Kate), from interview transcriptions and lesson dialogue, are included in the following descriptions of the categories. The lesson was dominated by Category 1 practices and therefore these are more fully explained in this short paper than the other two categories.

Category 1: Pedagogical Practices

Pedagogical practices refer to the teacher's practices that were chiefly concerned with the mathematical content and the students' learning of this content. Most of the one-to-one interactions that took place during the lesson involved these types of practices. Within this category, the following themes were identified:

Promote mastery orientation. Kate explained that maintaining an emphasis on student understanding requires the teacher to be flexible and adapt lessons to appropriately match the students' abilities. The emphasis on student understanding promotes *mastery orientation* (Adaptive Cognition quadrant of the M&E Wheel – Figure 1), which is associated with intrinsic motivation and is therefore a critical element of student engagement. There is also a link between mastery orientation and self-belief, suggesting that student success, achieved by mastering the content, increases their self-belief (Martin, 2007).

Encourage student self-regulation - Kate said that she assists students to "claim ownership of their learning" by allowing them to choose the 'ability' group they work with each lesson, and by encouraging students to reflect on their learning through questions such as "What did you learn?", and by pressing students to identify their preferred learning style. Kate gave the example of "We discuss in class...what kind of a learner are you? Do you need pictures? ...Are you good at listening to people?" Self-regulatory behaviours (planning, task management and persistence) comprise the adaptive behaviours of the M&E Wheel. They correlate to a mastery orientation and have been found to be conducive to both motivation and achievement (Martin, 2007).

Assess student understanding. To keep track of student understanding, Kate discussed the importance of monitoring, questioning and one-to-one conversations, stating in the pre-observation interview "It's a good way to pinpoint children where they are" and that she asks students having difficulties, "What can't you do?" since "If you don't ask them, you don't know". This was reflected throughout the lesson where Kate spent much of her time moving between students to monitor their progress and frequently assessed their understanding through comments such as "Ok. Show me what you've done", "How'd you go?" and "So did you do the figuring out...in your head? Or did you work it out on paper?" Monitoring student understanding in a manner that does not diminish a student's self-regulation corresponds with behaviours of planning, task management and persistence (M&E Wheel) that are positively associated with motivation and engagement.

Support students experiencing difficulty through prompting. Assessing student understanding throughout the lesson allowed Kate to support individual students experiencing difficulties with the task by providing prompts. Some of these prompts encouraged students to reflect on their thinking and included questions such as "Has that shown me that it's 4 lots of 3?" and "Is there a better way of showing...? Another way of showing?" Others provided clues about how to solve the answer, such as "But how many pieces do I need to cut it into?". Such prompts are intended to re-engage students in the task and allow them to experience a sense of accomplishment. Kate explained this was important "… otherwise they just find avoidance techniques. They go looking for other things to do. They are not feeling it's something they are comfortable with or capable of doing." Martin (2007) affirms that success-oriented students exhibit high self-belief and control, both of which are positively associated with motivation and engagement. Such students are also less likely to participate out of fear of failure – an impeding cognition (M&E Wheel).

Extend students when ready. This was evident in Kate's responses to students who correctly completed the task, such as "Can you draw it another way?", "Try another number where the top number is bigger than the bottom one" and "Can you do...this one's a double digit number, 14 over 12." Maintaining an appropriate level of challenge supports mastery orientation and therefore is positively associated with engagement.

Encourage student reasoning. Another feature of Kate's interactions with individual students was her press for students to justify their mathematical thinking through reasoning. "I want them to look at what they do and prove it, like tell me why...Getting them to see and compare and to make a judgment about why and give a reason". During the lesson, this was demonstrated through questions such as "Why is that one different?"

and "How did you know to split that into four bits?" Through challenging students to develop meaningful understandings, reasoning can be linked to mastery orientation and, thus, may contribute to student motivation and engagement.

Category 2: Practices Contributing to a Quality Learning Environment

This category is comprised of the teacher practices that contributed to setting the social and emotional tone of the classroom. These practices helped to create a learning environment where students felt safe and supported and contributed to building positive teacher-student relationships. Kate explained, "It gives the children who are part of that group the sense that someone is listening to me, someone is addressing me". Three themes emerged from the data: a) *Building positive teacher-student relationships* – Kate showed that she cared about the students' feelings, respected and valued them, by being attentive, polite and asking how they felt; b) *Providing encouragement* - illustrated through a variety of verbal and non-verbal communications, nodding and smiling and the frequent use of positive reinforcement; c) *Managing the learning environment* – through brief individual verbal interactions, repositioning students in the classroom, saying student names, raised eyebrows or a light touch on the student's hand or shoulder.

Category 3: Nonverbal Practices

Throughout the lesson, Kate exhibited a range of nonverbal practices when interacting one-to-one with students. These practices concerned her use of gaze, facial expression, gesture, proximity and touch. These included maintained eye contact in conversation, smiling, attentive listening, and pointing. Kate spent much of the lesson moving between students to monitor their work, standing close or even kneeling so that the interaction took place at eye level.

Discussion and Conclusion

In Kate's class, with its emphasis on interactions as the basis for building understanding in mathematics, we see an example of *symbolic interactionism* in action. With this group of 'underachievers', Kate had established socio-mathematical norms with a pattern of one-to-one interactions, which has a strong influence on the learning opportunities for both the students and teacher (Yackel & Cobb, 1996). As the observations were confined to this particular group of students it would be interesting to see whether the same interaction patterns were present when she taught the other two 'more advanced' groups of students.

The findings of this study resonate well with other research that has shown that effective teacher interactions focus largely on mathematical thinking (Cheeseman, 2009), and that monitoring student progress and providing prompts or extension is effective for supporting student motivation and engagement (Clarke et.al., 2002; Hackenberg, 2010; Sullivan et al., 2006). There was clear evidence that Kate deliberately attended to all three types of engagement, that is, behavioural, emotional, cognitive (Fredricks et.al, 2004), but placed particular emphasis on cognitive engagement. Many of Kate's practices aligned well to facets of the M&E Wheel (Martin, 2010). As such, it is possible that the high levels of motivation and engagement previously identified in this class were a result of the teacher's practices that encouraged students to adopt thoughts and behaviours known to increase student motivation and engagement.

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