SUDDENLY, WE HAD ENGAGED MIDDLE YEARS STUDENTS! HOW DID THAT HAPPEN?

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The atmosphere in a Year 9 class with 'usual Middle Years disinterest' changed during a problem solving session in which a 'resilience-building' approach to learning maths was used. This paper explores influences on that change and discusses implications for Middle Years maths learning.

Introduction

Middle Years research shows that lack of autonomy is a reason why students disengage from learning and become alienated from school. The way maths is generally taught in many classes, by presenting fragmented sets of rules and procedures, exacerbates this problem. Students in such classes do not have opportunity to think about "Why these rules?" Why do they work?" They are limited to applying the rules and procedures in the seemingly abstract contexts in which they were taught, or to rely on teachers to tell them which to use as new contexts arise. They are 'learned helpless'; reliant on others to tell them what to do. It is no wonder that so many students hate maths, problem solving in particular, and are unable to explore unfamiliar problems. This paper is about a session in a Year 9 class in which students were encouraged to become autonomous learners, making meaningful decisions about what maths to use, and how to use it, and what the results meant. The authors and the school are introduced, along with the purpose of Gaye William's visit to the school, the task, the approach, student responses, and our observations and reflections from the session.

Murrayville Community College and the Authors

Brad, a secondary maths teacher who taught this Year 9 group Science, is interested in finding ways to make mathematics more meaningful to students, and engage them in the process of learning maths. He described the students as coming from a very rural background in which mathematics can be related in a practical way to their life-worlds. He has found that students tend to find it difficult to draw on previous content when they are problem-solving.

Brenda, who travelled to Melbourne over several years in the 1990s to undertake her PhD about how teachers' perceptions of algebra influence the ways they teach the topic, has developed a rich understanding of what can affect the ways students understand algebra. Thus, Murrayville Community College have benefitted from an on-site researcher over time. Her **purpose** for inviting Gaye to Murrayville Community College (MCC) was to support the staff in their endeavor to deliver Mathematics in a fresh and relevant manner that takes into account the way students learn. The MCC staff focus for 2009 is to engage students in the language of their subject area. The language of Patterns and Algebra was the mathematical focus. Brenda sees MCC staff as aware of the difficulty students have in making the transition to using mathematical language in meaningful contexts. She was very familiar with Gaye's approach to mathematics learning and considered a visit would help staff to recognized that students can be advantaged where teachers model correct use of mathematical terms.

Gaye, a secondary mathematics teacher for more than 25 years, and researcher for the past 15 years, has designed and refined tasks and studied their implementation to increase deep student thinking about what maths could be appropriate, and how to interpret and make decisions about the maths students generate. Her research is framed by what she learnt as a teacher. Martin Seligman's work 'The Optimistic Child' helped her identify a characteristic that helps students problem solve: resilience (Williams, 2003). Gaye considers that the way her approach supports the building of optimism was key to what happened at MCC.

Gaye was intrigued with Brenda's wording about what her visit might achieve in relation to an increased staff awareness of how students can be advantaged by "teachers model[ing] correct use of mathematical terms". Gaye had never thought of what she did as 'modeling correct use of mathematical terms' because in general she does not introduce mathematical terms until after students have developed and expressed new conceptual ideas in their own language. She then introduces the term: "Mathematicians call that …". As students already have an understanding, the term becomes an attractive way to replace a longwinded articulation of an idea. Each student continues to make their own decisions on whether to use the new term or not, and Gaye uses both the common language and technical term in subsequent conversations until most of the class are using the mathematical term. This can take minutes or lessons. Gaye is pleased to have a new way to describe a part of her 'practice': model for teachers of a way to introduce new mathematical terms. Thanks Brenda!

Summing Up The Purpose

What the Maths staff sought was examples of specific tasks and delivery of their content so that they might have a model to emulate to incorporate the use of high level, meaningful, contextual language into classroom discussions. Gaye agrees that the approach she uses to build optimism fits with what MCC are looking for: to increase student understanding and communication of mathematical ideas using correct mathematical terms (eventually). Teachers sought tasks that might engage students in sufficiently sophisticated mathematical reasoning that they would need to communicate with each other through mathematical language. Such tasks were to provide teachers with the opportunities to validate students' use of mathematical language, build on their language, and develop a consensus of understanding within the classroom of specific mathematical concepts. Gaye designs and implements tasks that enable this to happen. As you can see, there is a useful fit between Brenda's and Gaye's perspectives, even though they focus on different aspects of problem solving situations.

Gaye visited three composite classrooms (in primary, middle, senior, school) on a one-day visit to MCC. Brenda arranged for as many teachers as possible to be released at a time during the school day to observe and discuss these sessions. Gaye had designed and modified tasks that she knew from experience were likely to engage students, show their potential to use mathematics meaningfully, and provide opportunities for them to create new understandings, and 'take on' mathematical terms to describe their learning process and understandings. The Year 9 class worked with the following task.

Calling the Race

This task can be completed without a graphics calculator. Graphics calculators are not to be used during the initial exploration of the task, but can be used (if the group decide this would be beneficial) after the problem has been explored and mathematical ideas have been generated.

Three animals run a 400-metre race. The distance of each animal from the starting point at any time **t** minutes is represented by one of the equations below.

D1 = (t – 2)(t – 10)(t – 18) + 200

D2 = t(40 – t)

D3 = 21t

D1, **D2**, and **D3** represent the distance in metres of each animal from the starting point at any time during the race.

1) Draw three graphs (on the same set of axis) to show the distance of each animal from the starting point at any time *t*.

2) You are the commentators calling the race. Decide what you are going to say to make an interesting story.

Task Features

This task, like Gaye's other 'conceptual tasks', contains certain features. These features are listed and include brackets with illustrations from this task:

- There is some sort of engaging twist to the task (select own animals, winner not easily apparent)
- More than one solution pathway possible (e.g., generate specific numerical values, develop and inspect tables of values, sketch rather than plot graphs by considering nature of algebraic equations)
- Multiple solutions are possible (e.g., the animals chosen, the narratives constructed)
- Students have not been taught a procedure for solving the task (linear and quadratic functions not in easily identifiable general form, cubic new)
- Students have sufficient background knowledge to access the task in some way. They might try specific values, finding patterns (e.g., types of graphs) or investigate why the pattern works (e.g., linking specific values and graph shapes, and algebraic form or linking slope and rate of change of animal's position)
- Solution pathways can be focused through various representations (e.g., verbal, numerical, tabular, diagrammatic, algebraic, graphical, logic)
- Transfer between representations is integral to solving the task (e.g., the narrative required will link verbal with other representations)

- Task questions stimulate the use of various solution pathways which can be used for students to check the reasonableness of what they have found (e.g., numerical, tabular, graphical, and algebraic approaches)

(For further information on this please see Tadich and Williams (2004) for other student responses, including a change in student disposition relevant to the present paper, which focuses on influences that can bring about increased engagement and understanding.)

Our Observations and Reflections

Brad

The session displayed a team problem solving approach in which students were able to collate all their ideas in order to solve a particular mathematical problem. This was quite advantageous; it meant that students who have strengths in a variety of different areas were able to display them, and in turn were able to promote ideas for other students, and build on ideas of others as well. Students had to work in groups that weren't particular friendship groups (see Williams, this publication). This provided a number of positive aspects including the fact that students weren't distracted by their friends. It also built constructive relationships within the classroom and it meant that students were getting new perspectives and ways of thinking. Each student had a group role: i.e. recorder, timekeeper, encourager, reporter which changed after each reporting session. Consequently, students who often had trouble concentrating were constantly engaged with the task at hand. Another positive with this type of lesson was that it gave those students that often struggled in mathematics confidence as they were prompted by the group as to what to report back to the class. This was particularly noticeable in one student who normally lacked confidence in mathematics. It made a difference to this student that they didn't have solve the problem completely on their own, but could draw on the understandings of others in their group. What the task also provided the students was the chance to visualize whilst problem-solving (concrete not abstract situation). As a teacher I see this as very positive. I could draw back on such visuals later for students. This has stimulated my thinking! I want to develop other such problem-solving tasks over many more content areas.

I need to consider: a) time availability, it really requires a double lesson for it to be completely effective; and b) how to stop myself providing the answer to students when they ask; taking a more passive role in the classroom so students work on their own in their groups. This will be difficult to get used to!

Brenda

From a professional development point of view it was wonderful to have the opportunity for teachers to observe their students while another teacher taught the class. A significant amount of reflection was possible during the course of the lesson as the students worked and engaged in dialogue with each other and Gaye. What was particularly interesting was the level of engagement and sophistication of language of, generally, off-task students during the Year 9 class. From a personal perspective, I found it wonderfully useful to view students from a class, other than the one I teach. We seldom have the luxury of "seeing" other students developing understanding from the safe position of viewer. I could see some students develop an air of confidence as the lesson progressed. A student who had a habit of purposeful disengagement, was found to be "in" the task early in the lesson and was quite forthcoming with ideas, expressed in quite articulate mathematical terms. For example, I remember the student saying ".....racing more rapidly than ... and overtaking .....". This student had gained significant insight into the rate of change notion of the creature racing. This is one of those "Big Ideas" we strive for in the Middle Years Mathematics classroom. Another student with a culturally different background, expressed her personal emotion throughout the activity and was able to relate the equations and variables to her `culturally grounded experiences. I believe this is what we, as teachers, need to strive for. We need to find ways in which students can experience mathematical concepts but take the next step: to use activities in which students feel a need to articulate, in mathematical terms, those experiences gained from the task.

The Calling the Race task engaged three of my 11 students who had, in their general education, found Mathematics uninteresting or difficult, and it also challenged the two students who were usually quick to complete given topic content. They found that they needed to do some deep thinking to grapple with the overarching concepts involved in the task. It was interesting that the younger students (Year 9) embraced the open-ended tasks while the older students offered more resistance. For me, this was evidence of the need for teachers to develop deep understanding of mathematical content through students' personal reflections and teacher modeling of language early in their schooling, and continue this through into the senior years with some consistency. I believe it is important for teachers to share a general understanding of what the overarching concepts in mathematics are, and come together to share ideas as to how they can project conceptual understanding into the classrooms. Gaye provided us with some insightful examples of engaging mathematics tasks, but also provided us with food for thought as to how we can look at subject content, pull out the big ideas, and think of ways we might get students to feel those ideas in a personal way while wanting to express those experiences in informal and formal mathematical language, using multiple representations.

Gaye

Gaye has described how she waits for students to describe new ideas in their own language before providing a term, BUT, why did they interact and discuss maths? This was not the usual behaviour of this class and many teachers tell her they are not yet able to generate such interactions in their classes. Gaye identifies contributing factors as: group composition (Williams, this publication), the accessibility of the task and its potential to elicit thinking about 'big ideas' (Williams, 2007). Also important are the absence of teacher hints or answers, teacher questions (without affirming, or 'correcting'), teacher suggestions of possible things to report on (see Williams, 2003), and teacher valuing of partial contributions to the class' understandings following each report.

In relation to issues Brad identified, Gaye suggests that leaving a task 'hanging' overnight can result in some productive thinking from students. In addition, the longer time taken in developing ideas in this approach, is often be made up for by the faster completion of exercises because student understanding is deeper. Students may not need to be 'taught' every twist and turn.

Brad's initial impression of the teacher being more 'passive' in these lessons is a common first impression, but further analysis shows that the complexity of teacher actions increases. It involves careful listening and working out what question you as teacher could ask to sustain the interactions. Both Brenda and Brad have identified the increased confidence that students developed because they had the ideas of others to work with. It is the teacher drawing attention to aspects of the conversation without affirming or saying 'you are wrong!' which helps to sustain these conversations and gives students the chances both Brad and Brenda identified: chances to learn from each other.

Brenda, Brad and Gaye also consulted on what each group knew before each reporting session, and placed reports in an order that supported the building of knowledge, and made sure each group had something new to say. This made a big difference to opportunities to develop new understandings, and to valuing each group's work. Instead of 'praising', Gaye selected something in each report that contributed to the understanding of the class, and drew this to the attention of the class with thanks to the reporter and group. Instead of a 'passive' teacher, we have a teacher who is flexibly adapting their 'moves' to the present needs of the students.

Influences on Engagement

Gaye considers the first reporting session was the turning point for this class. They suddenly realized it was safe to *think* and to put forward their own ideas and that these would be valued. This fits with Martin Seligman's (1995) work on the optimistic child. He says that due to parenting trends 1960-1990, parents and teachers helped children by 'doing the task for them' then praising them for doing it. This built learned helplessness. Perhaps it is no coincidence that the amount of adolescent depression doubled in the US through those years. Seligman (1995) advocates letting children struggle with problems that are almost out of reach, supporting them as they came closer to success, and valuing what they achieve. These successes achieved through individual effort can build optimism over time.

One example of valuing rather than praising is now reported.

> One of the first groups tried to explain what the 'letter' D meant before any other group had discussed pronumerals or variables. My response was of the form: "This group has alerted us to something very important. When mathematicians work with equations, they are careful to make clear what this group has called 'letters' are clearly explained so others know what the equation is about. This group has alerted you to the need to make this clear. You can think about what this group thinks D stands for and whether you agree and you may or may not decide to discuss something about this in your report. By the way, 'letters' is a good start for us and we do not want to hear more right now, but in another report, a group might like to discuss what mathematicians call these 'letters' [hand go up or someone starts to call out] NOT NOW! In your own report or in the summary at the end!"

'Unpack' and think about all the messages within. By the students realizing they are 'safe' many came to a stage where they were quite enjoying giving reports. They had realized that the answer was not what was important but rather progress on the way to knowing more.

References

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