Teaching mathematics in the middle years

Is middle schooling necessary?

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Background

It is recognised that young people between the ages of 11 and 15 undergo momentous physical, emotional and psychological changes as they move towards adulthood. A paper prepared as part of the Junior Secondary Review in South Australia describes adolescence as:

> ...a significant stage of life in its own right. Rather than being a way station between childhood and adulthood, adolescence has its own characteristic elements and challenges. Adolescence is a construct defined by social, biological and other factors. This view that adolescence is in part socially defined implies a significant role for school in shaping adolescence. (Cormack, 1991, p. 5)

If students in this age group form a specific group of people then it must be acknowledged that these people have needs which are specific to them, and that possibly these needs are not being met in some current school environments.

The concept of 'middle schooling' changed somewhat during the 1990s. Over the course of that decade and into the early twenty-first century, educationists and educational systems and institutions recognised that it was not always possible to build 'middle schools'. Neither was it possible to implement 'middle schooling' across the middle years of an existing school organisation and to set about attempting to meet the needs of adolescents.

Many schools have implemented middle schooling practices, that is practices implemented as part of a deliberate school strategy to meet the needs of early adolescent students, and in particular as they make their transition from a primary school setting to a secondary one.

It is not the intention to attempt to provide a definitive answer to the question posed in the title of this paper. Indeed, I am not sure that is possible. What I will try and do is provide an informative backdrop for some professional discussion for teachers of mathematics who teach middle years students in their classrooms. I will also attempt to draw out some likely implications of the generic discussion presented, for mathematics teaching in the middle years.

Characteristics of a good learning and teaching environment

Research into the middle years of schooling began in earnest in the late eighties and early nineties. It was prompted by recognition that many students in schools were being socially 'alienated' and disengaging from schooling largely as a result of the teaching and learning practices which had predominated in schools for generations. The alienation and disengagement was being exacerbated as a result of societal changes such as 'the escalating diversity of cultural, social and economic background of the students in our classrooms and the increasing impact of new communica-

tions technologies' (Carrington, 2004). Needless to say, ten years further on, these changes are now increasing at a greater rate.

The alienation that raised its head predominantly in the 1980s was apparently greatest for students in their early years of adolescence and consequently resulted in a plethora of research into teaching and learning in the middle years. The research resulted in acknowledgement that teaching and learning for all phases of schooling needed to change; that the world is changing rapidly for society as a whole and that as a result, traditional methods of teaching and learning may not be effective for many students. Research into students in the middle years revealed that because of the nature and characteristics of adolescents (see below) it was this group of students that appeared to be most affected by the outdated practices of many schools and teachers.

This research coincided with research in the 1990s concerning brain-based learning, and in particular, what formal education can learn from research findings about how people learn. The research supported the need for traditional teaching and learning programs in schools to change for all children regardless of their age or phase of development. Current national and international research is revealing that what 'makes the difference' for particular subgroups of the student population (for example boys, Indigenous students, adolescents, students in the early years) is good teaching and learning programs. The research identifies what makes a good teaching and learning program in a school. Desirable outcomes can be grouped under the domains of pedagogy (the teaching and learning practices that promote and lead to engagement and learning), curriculum, school leadership that supports the provision of a productive learning environment, organisation and structure that enhances learning, professional practice, community connections and partnerships that make parents, the community and the school partners in the process of educating each student, student support that ensures students can access the learning by feeling safe and supported, and various forms of assessment that guarantee standards.

In the first instance, schools should aim to ensure that high quality practice under each of these domains is in place before attempting to attend to the specific needs of student subgroups. That is, to attempt to put specific programs in place to attend the needs of subgroups before ensuring that every attempt has been made to address the quality of teaching and learning programs for all students, may result in failure, or at the very least, ineffective programs.

For the purpose of this paper I will assume that the reader is reading from a position where high quality practice is already in place in the school and that what he/she is interested in is that dimension which addresses the specific needs of adolescents in schooling. In addressing questions about what that might be, it is essential to begin with a discussion about the characteristics and subsequent needs of this particular subgroup.

Characteristics of adolescents

It is recognised that young people between the ages of 11 and 15 undergo momentous physical, emotional and psychological changes as they move towards adulthood. Cormack's description of adolescence above (1991, p. 5) recognises it as a significant stage of life in its own right. Other writers, including Eyers (1992), Hargreaves, Earl and Ryan (1996) and Sagor (2002) identify specific characteristics of this stage of life. They would concur that adolescence, as a specific stage of life:

- is related to a 'youth culture':
  - a low premium is placed on textual analysis,
  - a high premium is placed on other forms of immediate communication (TV, video, computer, films, magazines, music, text messaging, creating and broadcasting online zines, websites and videoclips),
  - it exalts energy and movement,
  - it develops its own fashion and idiom of expression (e.g. rap, tagging);
- is influenced largely by peer group;
- is characterised by young people needing to have their own space;
- is characterised by a need for a caring, challenging and purposeful environment with well-understood limits;
- is characterised by a need for rewarding but non-dependent relationships (requiring extended productive time with teachers);

- is characterised by a need to be discretely affirmed and supported by adults;
- is characterised by thinking in ways which become progressively more abstract and reflective;
- becomes increasingly more aware of the social and political world and gains skills in being resilient and participating in these different worlds;
- establishes and maintains relationships with significant adults, who can provide advice and act as role models;
- progressively develops a sense of identity through opportunities to explore their capabilities;
- progressively develops a sense of personal and social values which become part of that person's life;
- needs to experience social acceptance, and gain affection and support among peers of the same and opposite sex;
- is strongly shaped through achieving success in significant events;
- gains experience in decision-making, and in accepting responsibility for these decisions;
- grows towards independence while still needing security (a 'guide on the side') in many personal relationships and structures (such as school);
- needs to feel competent;
- needs to feel useful;
- needs to feel potent;
- needs to feel optimistic.

A word of caution: paying attention to adolescent characteristics should not result in stereotyping all students in the middle years. The fact that adolescents become more aware of the world around them can result in feelings that contribute to alienation, which in turn can manifest itself at school in disengagement. Both alienation and disengagement will no doubt remain constant in our schools as a result of continual societal changes. Mau (1992) identified four sociological dimensions of alienation that have relevance to the context of schooling. These are

- powerlessness (feelings of lack of control);
- social estrangement (feelings of social and/or physical isolation);
- meaninglessness (irrelevance and not connected with current experience); and
- normlessness (lack of direction and resultant rejection of social norms and rules).

The characteristics of adolescents combine to create these dimensions of alienation frequently through the way in which the curriculum is delivered, that is the content taught, the pedagogical strategies used and the assessment methods applied to ascertain learning.

Implications for teaching mathematics

There are some implications for pedagogy that emanate from the above list of characteristics — for teachers of any subject including mathematics. If possible, we should use information and communication technology (ICT) as part of the teaching and learning program; and in assessment, we should limit didactic teaching strategies and minimise copying from the board. The use of peer tutoring and group discussion is likely to increase engagement of students. We need to demonstrate care for individual students and this can be accomplished by demonstrating an interest in students' lives outside school and in students as individuals with individual aspirations and interests. It can also be demonstrated through the provision of meaningful feedback, written and oral, that tells students what they need to improve and how they might go about it. Students need to be discretely affirmed by us; adolescents need constant praise and encouragement, but not publicly.

Contexts for mathematics learning should be relevant and meaningful for adolescents moving into a world of adults and trying to make sense of issues; social justice issues in particular are a great context for teaching mathematics that engage and interest adolescent students. Questions such as:

- Are the rich getting richer and the poor getting poorer?
- Are taxes fair?
- Is the amount of forest on the Earth's surface decreasing?

are engaging but also impose great contexts for learning about percentages, proportions, fractions, trends, and many more mathematical understandings that will be deeply understood and remembered as a result of the meaningful context and application.

Open-ended discussions and tasks such as

these also enable all students to contribute and have some level of success, give students opportunities to work collaboratively, take responsibility for their learning and require them to make decisions — all skills needed by competent adults.

We should also make our expectations clear to students. Statements like, 'This week we will be learning about…' and 'I will expect you to develop some deep understandings about…' set the scene for students to know exactly what is expected of them (incidentally, this is even more imperative for boys), and to raise self-esteem and empowerment through the setting of high expectations for every student. These students need to know that their teachers believe in them and in their ability to achieve.

We also need to provide meta-cognitive time for student reflection on their learning; time to think about what they have learned, what they have struggled with, what they need help with, and so on. Adolescent students need the opportunity to express this as a means of taking some control over their learning.

In order to reduce feelings of powerlessness we need to give our students 'a say' in what they are learning. Relevant and interesting contexts might only be half as engaging if they are selected by the teacher. 'Negotiating the curriculum' does not mean a 'free-for-all' approach to what is taught and learned. A colleague of mine recently shared a story of her Year 10 class, not necessarily bound for higher mathematics instruction. At the beginning of the year she asked them to find out what mathematics they needed to know for employment they had chosen for the future. Following some extensive research where students worked in pairs to help each other, they generated a list of mathematics topics. With their teacher, and through a consensus process, they produced a list of topics they wanted to study and proceeded to do so. Even for students who move on to post-compulsory study and higher mathematics, students can be empowered by questions such as, 'We have to learn some statistics, some algebra and some matrices this term: what order would you like to do them in?'.

Similarly with assessment, once it has been made clear to students what they will be learning and what learning is expected of them, we might ask, 'How do you want to demonstrate your learning of this to me? You can choose from a power-point presentation, a written test, or a wall chart.' We might even open it up completely and ask them to choose the format or form that they want to use to demonstrate their learning; this will largely depend on how comfortable you are with making judgements about learning outcomes. By stating this at the outset, students will have more power over their learning, constantly thinking about what they are learning and how they will demonstrate it.

Attending to the specific needs of adolescents in the transition from primary school to secondary school

Many societies value the social benefits of a shift from the primary school setting to the secondary school setting. For many students this transition means a total physical and subsequent emotional relocation and this does not come without cost for a large proportion of students. For other students the experience is highly exciting and rewarding. Students often look forward in anticipation to making the change and see the move to a high school setting as a significant 'rite of passage' into adulthood.

Ferguson (1998) and Churchill (2000) have identified several factors associated with this relocation which they believe have an impact on students in transition. These include:

- loss of role model or key adult with whom to identify;
- loss of trust and diminished responsibility in the move from the most senior to the most junior in the school;
- decline in attitude and levels of motivation and interest in school and schoolwork;
- loss of sense of belonging and status through changes in established peer relationships; and
- the environmental changes from the closeted 'childish/feminine' environment to an independent 'adult/masculine' environment. (Churchill, 2000, p. 4)

The transition from primary school to high school often involves a number of significant changes for these students. Many students are required to move from:

- a small school to a large school;
- an integrated classroom style to a school organised by separate subjects;
- a setting in which they are the oldest students to one in which they are the youngest;
- a setting where they have a close relationship with one teacher to one in which they have many teachers but no close relationship with any one of those;
- having much responsibility and often a leadership role to having no responsibility or leadership role;
- being attached to one classroom to moving between rooms and having to take their own responsibility for being in the right place at the right time;
- interacting with a small group of peers to interacting with a large number of peers;
- being in a teaching and learning environment which required them to have few organisational skills to one demanding a plethora of these (e.g., coordinating the number of assessment tasks demanded by many more teachers), and
- a cohesive classroom environment where one subject frequently flows naturally into another and where time to complete activities is provided, to one which is unnaturally fragmented and time for sustained learning is unavailable.

It must also be remembered that although these are the issues that many students are initially confronted with at the point of transition between schools, they are physically, emotionally and socially going through a transition that lasts for many years.

While many students find these changes demanding, others thrive with the challenges that the changes demand. Jurisdictional data collected about students' literacy and numeracy results at Years 7 and 9 demonstrates that, for many students, there are no major implications for their learning in these areas of the curriculum (ACT Department of Education and Training, 2004). Other research indicates that there is a marked 'middle years slump' in student outcomes, including literacy and numeracy, and engagement (see, for example, Lingard et al., 2001).

Schools do however, need to be cognisant of the potential impact of the transitional factors listed above. Many schools make significant attempts to deal with the initial issues experienced as a result of the physical move from primary to secondary school through specific transition programs and practices. For example visits arranged for primary students to visit their new schools in the year prior to relocation; social occasions organised for students from either side of the transition to get together; orientation days where students from the primary school spend days and/or half days with their next year's peers and teachers, and so on.

Schools using these strategies frequently report success in supporting their students in making this initial transition from one school setting to another. This support however, is often very one-dimensional, focusing on student support in a pastoral care sense. What is often overlooked is the need to support the transition in an academic sense.

In order to make the transition a smooth one for students schools from either side of the transition need to work closely with each other to ensure that the academic transition minimises duplication and repetition of content and remains challenging for all students while at the same time, not making assumptions about what might have been previously taught or learned.

The need to be inclusive in this sense for adolescence, means recognising and valuing what students bring with them to the learning environment. This includes their often highly developed skills with technologies that too often, are not recognised or valued by traditional classroom practices.

Research has shown that a contributing factor to student disengagement and alienation results from students not being able to access what is presented in classrooms. This might be for a variety of reasons but the principle reasons are because it is too difficult, because students are being asked to cover work already done and because it is irrelevant to students and/or does not connect with their world.

We can attempt to minimise these effects by using a continuum of learning outcomes where we ascertain where 'students are at' prior to them coming into the high school setting. We can determine this through conversations with students' primary school teachers and through portfolio evidence of

student learning. We can also provide challenging learning for every student rather than waiting for them all to be at the same point in their learning before moving them on as a class (sometimes students learn very little new mathematics for six months or more when they begin high school and this can result in alienation and disengagement for these students).

Lingard et al. (2001) note that supportive environments are necessary but not, of themselves, enough to deliver improved outcomes for students across the middle years transition.

Schools also need to be aware that because the whole of the middle years is a transition period, it is insufficient to only address these factors at the transition point. Transition issues continue for adolescents well beyond Years 6, 7 and 8 and frequently into the post-compulsory years and beyond.

It is for this reason that 'long term' transition programs should be considered for students in high schools. Programs that focus on students exploring possible future pathways that bridge the compulsory/post-compulsory transition will not only assist students to develop a stronger sense of who they are, their capabilities and goals, but also indirectly support them through the entire transitional phase of adolescence.

Teaching mathematics in the middle years: Is middle schooling necessary?

'Middle schooling' describes a philosophy of schooling which attempts to respond more effectively to the specific developmental needs of young adolescents. It focuses on the characteristics and needs of adolescents and changes to school structures and organisations in order to do so (e.g., having the same teacher teaching the same group of students as much as possible in order to build strong relationships).

There would be many who would argue (and many have) that this approach supports and nurtures adolescents but does not necessarily ensure their engagement and learning. I do not think we need to be discussing an either/or situation. I think it is important to put structures and strategies in place that support and nurture adolescents and ensure engagement and rigour. This is why much of the research states that it is good teaching and learning that makes the difference for adolescent students.

So, I believe that 'middle schooling' does not necessarily require that we have learning teams and one teacher teaching five subjects, for example. These are only strategies to address the needs of adolescents — and many have proved effective, as indicated in the research. Other strategies can be used and the majority of them start with classroom teachers in their every day classrooms, as I have indicated above.

Concluding remarks

I really do not think that it is necessary for me to say much more. The implications for teachers of mathematics are fairly clear. The above description provides the backdrop for some rich discussion for teachers of mathematics who teach middle years students in their classrooms. It also provides some much-needed information for us about what many schools are trying to do and some rationale for changes we see being mooted or implemented in our comfortable, often 'traditional' settings.

We need to be reflecting on whether the way we do things in our classrooms is currently meeting the needs of our students.

- Are we boring them to death both with the content and the way we are teaching?
- Are they able to connect with what we're confronting them with on a daily basis?
- Are we using meaningful and relevant (student reality beyond school) contexts?
- Are we using learning technologies and information and communication technologies as much as possible both to engage and enhance understanding?
- Are there different things we can do as individual teachers to relate with our students on a personal level?

I also believe that we must be continually having a closer look at the content that we are including in our curriculum. One of the biggest arguments for secondary teachers not using more exciting pedagogical approaches, not using technology more, not allowing

students to have a say about how they want to be assessed and so on, is that there is 'not enough time — too much to get through'.

We need to get rid of about half of it, in my opinion. We need to teach what is essential for all students, not what is interesting or provides breadth or what is specialised, or what we enjoy teaching. We need to acknowledge that if our students are taught in ways that enable them to build confidence in their own ability as learners (see Perso 2003; 2004) then they will succeed at the next phase of schooling, be it Years 11 and 12, university, TAFE or in the workplace.

Let us get off the treadmill and have a good look around at how the world and our students and schooling are changing. Let us make some hard decisions about what is really important and what we personally can change in order to ensure that our students are firstly engaged and secondly, learning, to minimise the possibility of them being alienated.

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Diversions

SOLUTIONS

Why **odd** or **even**: if dots, say, are arranged in two rows, and even number will have 2 equal rows (even), an odd number will have one over.

Triangular numbers: 1,3,6,10,15,21.
Differences are the counting numbers.
In the Square, successive gnomons were 3, 5, 7, 9, 11, 13, 15. – odd numbers.
General term for them is $2n$-1.

In the table, add 28 and 36 for 7th and 8th T_n. Explanation could refer to differences increasing by one each time so the gnomons are the counting numbers 2, 3, 4, 5, 6, 7, 8 (revisiting this next issue).

Summary: missing words are: counting; odd; increase differences by 3; by 4; etc.

Quick adder: Various possibilities but the classic one is add the end numbers and multiply by half the number of terms!
So $101 \times 50 = 5050$.
This is the basis for the Gaussian summation used in arithmetic progressions.
The story? Karl Frederick Gauss was reported as being a boy in a class from which the teacher wanted a break. Teacher set the task, thinking it would give him some time for a smoke, and headed for the door. But the answer came back immediately from young Karl, whereupon teacher fumed and sent the impudent son of a brick-layer to the corner! He was to declare soon after that he could no longer teach this 10 year-old lad anything more of mathematics. Gauss went on to matriculate at age 15 and became a Professor of Astronomy at Gottingen at 30 until his death at 78 in 1855. One the giants of mathematics and science! Read more in any of many sources:
e.g., Hooper (1969), *Makers of Mathematics*, Faber, pp. 379–383.