Improving mental computation skills in middle years students

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Summary

The Middle Years Mental Computation (MYMC) strategy built teachers' conceptual knowledge and provided them with a repertoire of appropriate strategies for teaching mental computation meaningfully in the middle years of schooling. MYMC looks at changing how new skills are taught by spending a considerable amount of time using mental images and their manipulation prior to developing written methods.

MYMC developed students' conceptual understanding of whole and rational numbers. The MYMC diagnostic tool provided powerful information about class or individual students' conceptual development. It supported the analysis of error patterns to determine areas to be targeted and, in conjunction with the *Scaffolding mental computation* document, facilitated planning for targeted lessons. Pre- and post-testing of students using the *Middle years mental computation test* (MYMC test) in 2009 and 2010 showed a marked improvement in achievement in all areas tested.

> 'Explicit discussions were held with students about different strategies, resulting in children understanding that there is more than one right way to solve a problem and that you need to make a choice between strategies depending on the situation.'

The major factor leading to the development of MYMC was that the ACT Education and Training Directorate was a part of the Department of Education, Employment and Workplace Relations' (DEEWR) Mental Computation: A Strategies Approach partnership project. The research undertaken in this project formed the basis of the development of the assessment tool and professional learning package. This project supports literacy and numeracy of primary and secondary students, years 3–8, and their teachers. It was developed by the ACT directorate whose numeracy officers initially conducted the project with individual teachers, and then progressed to whole-school development. The project is extending to additional metropolitan schools in the ACT.

Dr Shelley Dole worked with the directorate numeracy officers on the development of an assessment DVD.

Target student group

Schools were selected for the implementation stages of MYMC (2008–2010) using a combination of criteria including:

- low Index of Community Socio-Educational Advantage (ICSEA) rating
- high schools with low NAPLAN results and their feeder schools
- using a cluster model to provide training.

Method

Aims

This strategy aimed to support the numeracy skills and understandings of primary and secondary students, years 3–8, and the pedagogy of the teachers within the directorate.

The strategy had three aims:

- to deliver professional learning targeted at building pedagogical content knowledge for teachers
- to build teachers' knowledge in mathematics in the sub-strand Number with a focus on mental computation of fractions and decimals, building fraction sense and a facility with efficient mental calculations
- to support schools to embed mental computation strategies in their planning and teaching.

MYMC aimed to increase teachers' professional knowledge, understanding and skill in connecting teaching, learning and assessment to support their students in learning mental computation strategies for addition and subtraction, multiplication and division, fractions, decimals, percentages and ratios.

Professional learning

The ACT Assessment Program (ACTAP) was designed to test literacy and numeracy skills in years 3, 5, 7 and 9 across the ACT system. Similar to NAPLAN, trend data and student growth was tracked, and results from 2006 identified an ongoing need for professional development to address teaching of numeracy to students in the middle years. A network of teachers who represented schools across the ACT identified multiplication, fractions, decimals and percentages as focus targets. Further data analysis using the MYMC assessment tool indicated that addition and subtraction also needed attention. A professional learning package was implemented to address this need.

> ‘Strategies learned enabled you to teach all areas in different ways. Loads of helpful resources are available to support learning (interactive whiteboard and Word).’

Two numeracy officers in the ACT Education and Training Directorate worked on developing and maintaining the MYMC professional learning modules and resources. To ensure sustainability, they adapted MYMC to meet the needs of the Australian Curriculum during 2010. Due to extensive demand from schools they developed a facilitator course that was also implemented in 2010. The numeracy officers worked with lead academics from around Australia on best practice. Professor Di Siemon presented workshops, annually, to school-based numeracy coordinators and selected staff on the *Big ideas in number* (2006a). Dr Shelley Dole worked with the directorate numeracy officers on the development of an assessment DVD.

ACT directorate numeracy officers initially conducted the project with individual teachers, and then progressed to whole-school staff training. MYMC was delivered to educators over eight 2-hour workshops. The workshops were structured to build from one concept to the next. The facilitators then assisted the school as they worked to implement the program with the numeracy coordinator. Seventeen facilitators have been trained to implement MYMC professional learning and coaching in schools. The numeracy officers regularly reflected on best practice and made adaptations to improve course delivery and resources.

Schools that completed MYMC professional learning were provided with *Mental computation: a strategies approach* (2004) along with a kit containing the testing system, and a USB of resources and reference books.

In classrooms

MYMC is a strategy that is relatively easy to implement in a school, bearing in mind that rethinking how to approach rational number teaching could challenge some highly traditional, textbook-based teachers. MYMC looks at changing how new skills are taught by spending a considerable amount of time using mental images and their manipulation prior to developing written methods. Traditionally, textbook teaching moves from point 1 to point 4, skipping quickly through points 2 and 3. The cycle below shows how MYMC approaches the teaching of each concept.

Mental computation development cycle

1. Students create and/or use **manipulative**/concrete materials.
2. Students are encouraged to develop **mental images**.
3. Students refine images for use in **efficient mental computation**.
4. Students derive **written methods** from their understanding.
5. Students **generalise** understandings to engage in more complex mathematics (move back to point 1).

When students were able to manipulate their mental images well, demonstrating strong conceptual understanding, they were then encouraged to develop their own way of recording their solution on paper (point 4). They then refined this approach with teacher support to develop efficient written strategies. This change, in not only the value of mental computation in a mathematics class but also the way students moved through the learning cycle, may need to be carefully introduced and supported in school settings.

> 'My attitude towards teaching fractions changed as well. In the past I had seen fractions as dry and boring, and did not look forward to teaching fraction concepts. Seeing how engaged the students were, and how much they improved, really changed the way I think about it. I was motivated to continue, and so were the students.'

The MYMC resource provided a comprehensive series of sequenced lessons from addition and subtraction basic facts through to ratio and percentage. Teachers were able to tailor and differentiate the curriculum for all students by linking the MYMC assessment tool and *Mental computation: a strategies approach* (2004).

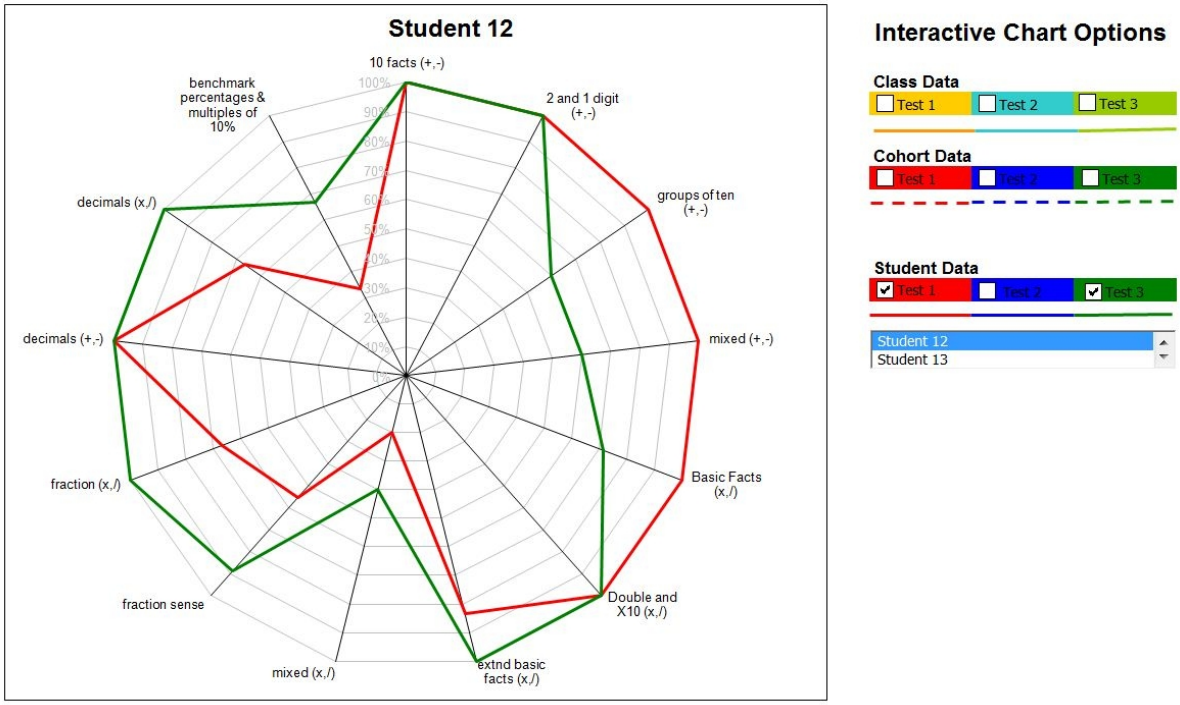
The MYMC test measured achievement in mental computation based on concepts or skills. This allowed teachers to use the results effectively in their planning. Teachers were provided with an Excel spreadsheet, which colour codes each concept or skill for easy reference, to record data. The analysis and planning from the assessment tool engaged teachers in discussion of pedagogical content knowledge – one of the main objectives of MYMC.

> 'The games get students engaged in the learning.'

The creation of a model for more targeted planning with class support was the culmination of the project. This model continues to be used with an increasing number of students, teachers and schools across the ACT.

Results

The Excel spreadsheet for recording student data was linked to a spider graph associated with documenting skills and concepts tested in the MYMC test. Each of the three tests was viewed on one chart to determine growth of either a class or an individual student. Student growth was quickly determined using the spider graph.



In 2010 student growth in terms of fraction sense was 28.59%, the percentage increase in student performance from test 1 to test 3 based on the MYMC test data.

NAPLAN testing data was analysed to determine if targeted MYMC lessons in year 6 would improve NAPLAN results above what might be expected. NAPLAN results from year 5 (2008) and year 7 (2010) were used in this comparison. This analysis included a comparison to a similar cohort of students with no MYMC exposure and to expected growth for all students (mean student residual). Results showed increased rates of growth in students who participated in the MYMC group and indicated the strength of the mental computation program in lifting numeracy results. It should be noted that a small sample size was used in this comparison and care must be taken interpreting these results.

Student surveys on attitudes and confidence were completed in the first phase of the implementation, prior to classroom intervention, and at the conclusion of the project.

The purpose was to determine if MYMC intervention would show that students made positive changes in attitudes and confidence in mathematics. Anecdotal records were kept by implementation teachers on their observations of students using mental computation strategies in other learning areas. Extensive lists of observations indicated the transferability of mental computation skills to other learning areas.

Comparison data was collected in 2010, specifically targeting year 5 and 7 students. Year 5 had a target group of 505 students and a control group of 110. Year 7 had a target group of 71 students and a control group of 89 students. Comparison data from year 7 results showed MYMC student growth between 11.97% and 17.23% in skills and concepts involving fractions, decimals and benchmark percentages. The control group data showed growth under 5% in fraction skills and negative growth in decimal and benchmark percentage concepts.

Pre- and post-testing of students using the MYMC test in 2009 and 2010 showed a marked improvement in achievement in all areas tested. Each mental computation skill was assessed at the beginning of the calendar year and a post-test was delivered at the conclusion of in-class teacher support from a numeracy officer.

Lessons learned

Many of the lesson ideas, strategies and concepts were designed for SMART Notebook. Without access to this software, MYMC would be more difficult to implement.

Parents who have a traditional, algorithm basis in mathematics may find it challenging to support their children at home. Schools need to consider how they can support and educate parents on MYMC skills.

> ‘What a difference this [MYMC] pilot has made to my school and community. There was a need to share with our parent community the great work we were doing with the senior students in mental computations, and for them to have a clear understanding of what “mental computations” were. We had approximately 55 parents turn up. They were treated to a hands-on hour long “lesson” and by the sounds and laughter all participants had a good time. For many it was back to school in terms of learning the strategies we teach students when working mentally and understanding the importance of “So, how did you work that out?” Parents took home a resource pack which included dice and the 0–11 cards. It was quite evident that many parents valued the card activities because students were coming to school saying that they were playing some of the games with their parents. Many parents caught up with me over the following days to say how much they had valued it [and that they had learnt] to “have fun with numbers”.’
>
> (Teacher, 2010)

MYMC is a program that could be readily adapted to school and district needs. MYMC can be delivered as a cluster model to primary, middle and high schools, or as a centrally run professional learning program. The following will need to be addressed to promote success in implementation.

School-based professional learning requires:

- suitable time allocated for staff to be effectively trained (8 x 2-hour modules)
- trained facilitators
- a whole-school commitment
- the school-based numeracy coordinator to be up-skilled through modelling of lessons, using a gradual release of responsibility model
- the availability of SMART Notebook
- test data from NAPLAN and the MYMC diagnostic tool.

Next steps

Work is currently underway to create a new assessment tool for students in years 1–4. This professional package, developed in consultation with Dr Shelley Dole, will enable more students to access the program.

> ‘Learning how the activities and interactive whiteboard resources can be used from early years helped us to bridge the K–6 number-sense gap. Also, knowing the theoretical basis that underpins the MYMC resource is valuable.’

MYMC is an endorsed program for ACT schools. When numeracy coordinators attend centrally run training sessions they are exposed to MYMC. From here, many of these coordinators book in MYMC sessions for their school after approval is granted from their principal. Word-of-mouth and teachers transferring between schools is also helping to promote the success of the program.

Research base

The MYMC strategy came out of the DEEWR Mental Computation: A Strategies Approach partnership project. The research undertaken formed the basis of the development of the assessment tool, with aligned resources to support teachers’ assessment of each student’s achievement in mental computation. Understandings gained through the professional learning were embedded in practice.

The testing tool was developed in consultation with Dr Shelley Dole who wrote several modules of *Mental computation: a strategies approach* (2004). The MYMC test was developed in 2004. The test was based on the questions used to develop the levels of achievement in mental computation from *Mental computation: a strategies approach, module 1* (2004). In 2008, the results from system-wide testing using the test were statistically analysed by ACT Education and Training Directorate numeracy officers in consultation with Dr Shelley Dole. Further information about the test development can be obtained from the directorate.

Northcote and McIntosh (1999) found that 85% of all calculations are completed mentally. It is interesting to note that pen and paper techniques counted for 12% of all calculations and 8% of all calculations involved the use of a calculator. With this in mind, MYMC was designed with a focus on addressing the imbalance currently experienced in schools, where traditionally algorithms and rule-based learning were the focus of mathematics lessons.

> 'My role as numeracy coordinator sees me taking all year 3/4 classes as well as the year 1/2 classes for one mental computation session a week. At present I am modelling the sessions to staff with a view to them taking over, down the track. I am very impressed with the responses from the younger students who show a keenness to explain how they worked something out. It is also very noticeable that all students look forward to these sessions as it is *maths without the pressure*.'

Other research used in the development of MYMC included publications from Professor Dianne Siemon (2006a, 2006b). Her research articles and papers were recommended reading for teachers engaging in personal professional development.

Further reading and links

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Contacts

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