Representations of Oral Language and Engagement in Mathematics

Summary

Representations of Oral Language and Engagement in Mathematics (RoleM) is a resource that provides support for early years teachers of mathematics, especially for those who work with Indigenous students, ESL students and students in low socio-economic status (SES) contexts. Teachers are supported through the provision of differentiated and developmental learning activities, hands-on resources, as well as a website with digital resources for electronic whiteboards and computers. The aim of RoleM is to improve students' success in engaging with the 'big ideas' of mathematics. This includes improving their use of mathematical language, their understanding of mathematical representations and their ability to think mathematically. The program also aims to improve teacher's knowledge and pedagogy in regard to early years mathematics.

Evidence for the efficacy of this approach comes from a number of quantitative and qualitative sources: students' results, teachers and Indigenous Education Officers (IEOs). These have shown statistically significant improvement in almost all students' results in schools using the strategy, and this has occurred in urban, rural and remote contexts.

Target student group

The RoleM strategy grew out of a pilot program with Foundation-aged Indigenous students in a number of locations throughout Queensland. It has been extended to include schools with high numbers of ESL students and/or students from low SES backgrounds who are seen to be at risk. It now operates in a range of education systems and settings, from urban schools to those in regional and remote areas. It is designed for students in years Foundation to 3.

Method

The strategy

The RoleM learning activities are designed to engage students and help them experience success in mathematics while exploring the 'big mathematical concepts'

RoleM resources focus on key dimensions (eg sorting and classifying, counting, positional language for space, comparing and ordering, developing an understanding of length) that are essential in improving student learning outcomes in mathematics.

1. Improving students' mathematical understandings

For students to become deeply knowledgeable about a particular concept, for example, Number, they need to see numbers represented in a variety of ways: as a set of objects, as different lengths and areas, as bars on graphs, and distances on number lines. The key representations used in the RoleM program are similar to those used in all areas of mathematics at all levels (eg grids and number lines). It is important that students learn the conventional forms of representations to facilitate their development of mathematical understanding and their communication with others about mathematical ideas.

2. Catering for different ways of learning

The program provides the resources, direction and learning experiences to assist students to investigate mathematical concepts using a variety of learning modes (eg hands-on, visual, kinaesthetic, verbal and symbolic) It also provides students with opportunities to work independently on activities.

3. Developing the ability to effectively communicate mathematical ideas and understanding about concepts to themselves and to others

Communication in mathematics consists of the language of mathematics together with an array of representations. It underpins all areas of mathematics and is particularly prominent in NAPLAN assessment. While most students experience difficulties with the language of mathematics, students from ESL, Indigenous and disadvantaged backgrounds commonly experience added difficulties. These students find certain patterns of classroom interactions, teacher questioning and mathematical concepts difficult to understand. The RoleM learning experiences and resources are designed to assist teachers to create an engaging context for students as they learn new language in conjunction with new mathematical concepts. As students experience success with the program their confidence to effectively communicate their mathematical understanding is enhanced.

4. Catering for a diverse range of learners

The RoleM learning experiences consist of three levels: consolidating prerequisite knowledge, engaging in the new learning, and extending the new learning. All of these can be readily adapted to cater for a diverse range of learners.

Support materials

The RoleM program provides Foundation, year 1 and year 2 RoleM resource kits to give teachers additional support.

Each resource kit consists of:

- a book of learning experiences that provides teachers with explicit knowledge of specific mathematical concepts and how to develop these concepts in the classroom
- a book of printable resources to use with the learning experiences
- a set of six laminated resources related to the learning experiences
- access to web resources
  - how-to videos for the learning experiences
  - links to interactive digital resources
  - interactive whiteboard activities and iPad apps
  - downloadable printable resources including additional resources not in the book
  - background readings.

For costing on establishing the RoleM program in your classroom, please refer to the [RoleM website](#) 🔗. Programs for Foundation to year 3 can be purchased separately or together. Discounts apply for purchases of two or more year programs. All resources are linked to the learning activities and are ready for classroom implementation.

The current resources have been developed over a three-year period and have been trialled in different contexts including metropolitan, regional, rural, remote and very remote locations. All resources have been deemed culturally appropriate.

Trialling materials

To develop the resources the project went through three cycles each year, with each cycle consisting of four stages: design, trial, evaluation and modification. The design stage was informed by the findings of the developers' previous research project together with the literature. The research literature focused on mathematics learning, Indigenous pedagogy, Indigenous assessment and student engagement.

The trial stage comprised professional learning and classroom trials. Participating teachers and IEOs underwent one day of professional learning in each trial stage. The focus was on sharing the materials developed in the design stage. Teachers and IEOs then trialled the materials in their classrooms. The RoleM team supported teachers and IEOs in classrooms to implement the learning materials.

The evaluation stage ran simultaneously with the trial stage. Teachers, IEOs, principals and parents/carers were invited to provide ongoing feedback on the effectiveness and appropriateness of materials for use in their community. Ongoing changes occurred in response to the feedback received. Modifications were made to the materials and they were prepared for publication.

Results

Types of data

Evidence comes from a number of quantitative and qualitative sources: student results, teachers and IEOs/Teacher Assistants (TAs). Student data were collected from pre- and post-testing results. Results indicate statistically significant improvement in almost all students' results in schools across all regions.

Before collecting data for the RoleM research project, tests were extensively trialled and reviewed in a variety of schools for appropriateness and efficacy. Teacher and Indigenous personnel were consulted about the development and administration of the pre- and post-tests to ensure questions were culturally appropriate and comprehensible.

To ascertain the effectiveness of the program, purpose-designed pre- and post-tests were conducted at each school site. To ensure consistency of delivery, tests were administered by trained RoleM staff. The tests reflected the structure of NAPLAN assessment.

Student mean data was collected from pre- and post-tests from the years 2010 and 2011. Data was also collected across a variety of categories: Indigenous and non-Indigenous; year level; urban, regional and remote.

To gauge the gain in students' understanding of mathematical concepts over each year of the program, a comparison was made between their pre- and post-tests results, and comparisons between different categories of participants and stakeholders were also made.

In addition, a series of individual interviews was conducted with classroom teachers, IEOs, and school principals. Teachers were surveyed and responses were documented.

Conclusions

Teachers reported increased confidence which has been integral to the success of the program. A deeper understanding of mathematics enabled teachers to recognise and correct errors that students made in their mathematical thinking processes and applications. Teachers were able to structure and support students' concept development and application and maintain momentum and consistency in their teaching.

School administration teams have been integral in ensuring similar consistency in students' mathematical development by:

- supporting the program's implementation across all classrooms and year levels
- cultivating and sustaining a community that is cohesive and collectively responsible for student learning
- providing organisational support and direction, and appropriate resource allocation.

'T2 (un-named teacher) who had previously taught in mainstream schooling was finding her feet in an all-Indigenous school in regional Queensland. She was battling with behavioural problems from students who were disengaged with mathematics. Through her participation in RoleM, she is now experiencing the benefits of engaging students with hands-on learning activities rather than the book-based focus she had been using. She now works closely with on her IEO on improving student learning as well as managing cultural and behavioural issues.'

Lessons learned

The inclusion of TAs and IEOs in the professional learning was paramount to students' success. Professional learning focused on the importance of oral language, how to use the resources, and how to effectively support the teaching of mathematical concepts. The teachers and IEOs/TAs formed highly productive partnerships for improving student learning outcomes, as less time was spent on explanations about what was required because the IEOs/TAs already knew. They often have a strong commitment to the local community which, when combined with knowledge and understanding of the mathematics program, can help maximise student learning.

A significant number of early years teachers were initially strong advocates for a play-based approach and were reluctant to embrace a more structured learning program. However, many were surprised at what their students could do when they saw them working on the program's activities.

The program also helped inexperienced teachers to organise their mathematics lessons. This was especially important in remote regions where mentor teachers were not always available to help.

Teachers and IEOs/TAs became more conscious of the importance of oral language and of the need to teach it explicitly during mathematics activities. As they became more confident they extended this knowledge into other curriculum areas and to incidental learning opportunities.

Next steps

Support of the implementation of a RoleM program in schools involves:

- promoting collaboration between teachers and TAs to focus on enhancing mathematics learning
- ensuring that adequate classroom time is allocated to the teaching of mathematics
- maintaining consistency in implementing the program across the year levels
- providing administrative support for teachers
- ensuring the program's materials are available to all teachers in a particular year level
- fostering collegiality and cohesiveness between teachers and IEOs/TAs
- ensuring IEOs/TAs are familiar with the program, resources and website
- supporting individual teachers who may initially be resistant
- providing professional development opportunities with RoleM staff to ensure that everyone understands how the program works and feels confident in their ability to change pedagogical practices.

'As T1, a first-year graduate, gained confidence in the program, she revealed that her instructional skills and pedagogical practices for effectively teaching mathematics were very, very poor. She saw this as a result of never 'experiencing interesting mathematics' when she was at school or in her undergraduate program, and her 'low expectation of [her] self' as a mathematics teacher. Being part of the RoleM project has facilitated 'radical changes' in how she now teaches mathematics.' (Teacher Interview Data 2011)

Research base

Research that has informed the development of the RoleM program includes the following sources.

The work of Krause, Bochner, Duchesne & McMaugh shows that oral language is crucial to a student's emergent mathematical development (2010). In the early years of formal schooling, an oral language approach to teaching and learning is appropriate due to the emerging reading and writing skills of students at this age. This is even more the case for students whose home language is not Australian Standard English (ASE). Without the necessary oral language skills to learn and understand the mathematical language used in instruction and assessment, students are unlikely to succeed in their mathematical development.

There is consistent research that indicates that disadvantaged students', especially Indigenous students', learning outcomes are assisted by general strategies such as:

- providing gradual learning progression, with practice to ensure students develop confidence and ability
- exposing students to a range of experiences and representations
- using various kinds of group work
- integrating experiences involving listening, reading, writing, recording and speaking about concepts to enhance transference of skills
- teaching directly or explicitly, using modelling and providing clear explanations of experiences
- using engaging hands-on materials and providing clear expectations
- using a variety of representations simultaneously (Cooper, Baturo, Warren & Grant 2006; Frigo & Simpson 2001; Warren & deVries 2009).

'On average, teachers rated the RoleM resource kit 4.3 (out of 5) and felt it had a positive impact on all aspects of their mathematics teaching, from increasing their confidence in teaching mathematics to developing a positive attitude towards mathematics in both staff and students.' (Teacher Interview Data 2011)

The RoleM pilot study results showed that young Indigenous students (average age 4 years and 11 months) were capable of engaging with 'big' mathematical concepts (Warren & DeVries 2009).

Teachers have a major impact on student learning in schools (Hattie& Timperley 2007; OECD 2004). Many teachers see mathematics learning as involving the use of a textbook with students completing written examples and work sheets in class. In this paradigm the emphasis is on students memorising and recalling rules (ed Boaler2000). For many early childhood teachers this pedagogical approach is perceived to be at odds with the dominant discourse of play-based learning. Children learn through play and need adult guidance to assist them to reach their full learning potential (eg Balfanz, Ginsburg & Greenes 2003; Vygotsky 1962).

Further reading and links

Balfanz, R, Ginsburg, H & Greenes, C 2003, *The big math for little kids: early childhood mathematics programs*, Dale Seymour Publications, Parsippany, NJ

Boaler, J (ed) 2000, *Multiple perspectives on mathematics teaching and learning*, Ablex Publishing, Westport

Cooper, TJ, Baturo, AR, Warren, E & Grant, EJ 2006, '"Aim high – beat yourself": effective mathematics teaching in a remote Indigenous community', in Novotna, J, Moraova, H, Kratka, M & Stehlikova, N (eds), *Proceedings of the 30th annual conference of the International Group for the Psychology of Mathematics Education*, Prague

Frigo, T & Simpson, L 2001, *Research into the numeracy development of Aboriginal students: implications for the NSW K–10 Mathematics Syllabus* , ACER website.

Greenes, C, Ginsburg, H & Balfanz, R 2004, 'Big math for little kids' , *Early childhood research quarterly*, 19, pp 159–66.

Hattie, J & Timperley, H 2007, 'The power of feedback', *Review of educational research*, vol 77, no 1

Kraus, KL, Bochner, S, Duchesne, S & McMaugh, A 2010, *Educational psychology for learning and teaching*, 3rd edn, Cengage

Warren, E & de Vries, E 2009, 'Young Australian Indigenous students' engagement with numeracy: actions that assist to bridge the gap' , *Australian journal of education*, vol 53, no 2, article 4, ACER website.

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