THE EUCLID PROJECT

Improving Middle Years Student Engagement with Mathematics through Action Research

Final Report

Associate Professor Catherine Attard
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>iii</td>
</tr>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>iv</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Background</td>
<td>2</td>
</tr>
<tr>
<td>The Euclid Project</td>
<td>5</td>
</tr>
<tr>
<td>Evaluation Design and Methods</td>
<td>9</td>
</tr>
<tr>
<td>GROUP 1: COOMA/JINDABYNE/MONARO</td>
<td>15</td>
</tr>
<tr>
<td>Group 1: Processes and Outcomes</td>
<td>16</td>
</tr>
<tr>
<td>Group 1: Students’ perceptions of mathematics</td>
<td>22</td>
</tr>
<tr>
<td>Group 1: Teachers’ perceptions of the action research process</td>
<td>24</td>
</tr>
<tr>
<td>Group 1: Next Steps</td>
<td>24</td>
</tr>
<tr>
<td>GROUP 2: JERRABOMBERRA/BUNGENDORE/KARABAR</td>
<td>26</td>
</tr>
<tr>
<td>Group 2: Processes and outcomes</td>
<td>27</td>
</tr>
<tr>
<td>Group 2: Students’ perceptions of mathematics</td>
<td>31</td>
</tr>
<tr>
<td>Group 2: Teachers’ perceptions of the action research process</td>
<td>32</td>
</tr>
<tr>
<td>Group 2: Next Steps</td>
<td>33</td>
</tr>
<tr>
<td>GROUP 3: QUEANBEYAN EAST/SOUTH/WEST</td>
<td>34</td>
</tr>
<tr>
<td>Group 3: Processes and outcomes</td>
<td>34</td>
</tr>
<tr>
<td>Group 3: Students’ perceptions of mathematics</td>
<td>36</td>
</tr>
<tr>
<td>Group 3: Teachers’ perceptions of the action research process</td>
<td>37</td>
</tr>
<tr>
<td>Group 3: Next Steps</td>
<td>38</td>
</tr>
<tr>
<td>GROUP 4: KARABAR DISTANCE EDUCATION CENTRE</td>
<td>40</td>
</tr>
<tr>
<td>Group 4: Processes and Outcomes</td>
<td>41</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

Funding for this study, *The Euclid Project: Improving Middle Years Student Engagement with Mathematics through Action Research*, was provided by the New South Wales Department of Education, Queanbeyan Network. The views expressed in this report may not be representative of the funding body.

The author wishes to express her sincere thanks to the Queanbeyan Network Director, Matthew Brown, for his initiation and support of this project, the teachers who volunteered to participate, their principals, and the students who took part in focus groups.

I also wish to express sincere thanks to John Ley who assisted with data collection and provided advice and feedback to the teachers in regard to mathematics teaching and learning.
EXECUTIVE SUMMARY

This report provides the findings of a study designed to investigate the effectiveness of a NSW Department of Education Queanbeyan Network initiative to promote and support teacher action research in middle years mathematics education. The process of action research requires teachers to identify a problem of practice and formulate, carry out, and evaluate a plan of action in order to improve educational outcomes. The intent of this initiative was to address low levels of student engagement and achievement in mathematics from late primary and across the transition to the early secondary years within the Queanbeyan Network.

Associate Professor Catherine Attard from Western Sydney University, and a research assistant, Mr John Ley, worked with 10 primary and 13 secondary teachers from NSW public schools in the Queanbeyan Network from August 2016 to November 2017. In 2016 the teachers participated in two professional learning sessions relating to effective pedagogy in mathematics education and the action research process. In 2017 the 23 teachers formed five action research groups and conducted their research from February to November. Teacher group interviews were conducted four times (once a term) and student focus groups were conducted twice (Terms 2 and 4). An action research showcase was conducted in Term 4 and the research groups also submitted a formal written research report to the research team.

Findings

Participation in action research resulted in varying degrees of change in the practices of the majority of the teachers involved. These changes led to some improvement in student engagement and improvements in teacher engagement.

The key findings were as follows:

In relation to teaching mathematics

- The amount of change resulting from action research varied from group to group
• Shifts that occurred in teacher practice resulted in a stronger emphasis on teaching through the processes of mathematics (Working Mathematically) rather than focusing solely on the teaching of content
• Teachers gained a deeper understanding of the mathematics curriculum and its application in middle years classrooms
• Mathematical problem-solving including comprehension and strategy development emerged as a common research focus amongst each of the groups

In relation to action research
• The groups working collaboratively across schools gained significant benefits of greater confidence and satisfaction in teaching mathematics
• The majority of teachers reported their personal engagement with the teaching of mathematics had increased as a result of their participation in the Euclid Project
• Groups that involved collaboration between primary and secondary schools gained greater insight into issues relating to transition and mathematics
• Collaboration across primary and secondary settings led to shared practices and a common language relating to mathematics
• The levels of support of school leadership influenced the levels of success of each of the research groups
• Teachers began to understand the process of action research as a practice changing practice

The findings from this study indicate that the participating teachers had begun to make progress in relation to improving their practices to ultimately improve the student experience during the middle years and in the critical period of transition from primary to secondary schooling. Although varying levels of success were experienced, the teachers had begun their journeys as reflective practitioners working in partnership with colleagues within and across schools. The following is a set of recommendations arising from the findings.
**Recommendations**

- Future professional learning opportunities in mathematics within the Queanbeyan network and beyond should focus on strengthening teachers’ understanding and implementation of the Working Mathematically strand to ensure it forms the core of their mathematics teaching.

- To assist in developing deeper conceptual understandings and problem solving skills school leadership should support teachers to focus on developing student conceptual understanding as opposed to timing teaching and learning according to the demands of scope and sequence documents.

- Teachers who were successful in their action research within the Euclid Project are encouraged to become mentors to other teachers within or across schools in order to promote a culture change in relation to mathematics education practices.

- Student voice in relation to mathematics teaching and learning should have more prominence in relation to programming, planning, and pedagogy in mathematics.

- Continuation of the relationships between the primary and secondary mathematics teachers who participated in the Euclid Project is strongly encouraged and should be supported by school leadership.

- Further opportunities for collaboration across the middle years of mathematics is strongly encouraged to ensure alignment in pedagogical practices.

- Support for participating teachers to continue developing the practice of action research is strongly recommended to ensure action research is an ongoing aspect of practice rather than perceived as a finite project.

- The use of an external critical friend in future initiatives is recommended to ensure accountability and to provide additional expert advice and support.

- Future iterations of cohort based action research should include an expression of interest process to ensure participants and school leaders are committed to the process.
INTRODUCTION

The Euclid Project was conducted in the Queanbeyan Network of NSW Department of Education schools. This project was initiated by the Network Director, Matthew Brown, against a backdrop of falling standards in mathematics at local, state and national levels. (Dinham, 2013; Masters, 2016). The project was the result of the Director’s vision and a series of conversations and meetings with colleagues and the lead researcher, a specialist in student engagement with mathematics. The philosophy underpinning the project was the shared belief that improved student engagement leading to long term academic improvement is ultimately driven by changes in teacher practice. Although the duration of the formal project activities was planned to span one school year, this was considered as a way to develop a culture of action research that would be ongoing, rather than simply the implementation of a finite project. In other words, promoting action research within the network as a ‘practice changing practice’ (Kemmis, McTaggart, & Nixon, 2014).

The teachers involved in the Euclid Project conducted collaborative action research projects to address a specific issue or issues relating to their student cohorts and mathematics during the middle years (Years 5 to 8) and across the transition from primary to secondary school. The research team from Western Sydney University consisted of a senior researcher and a research assistant, both of whom have expertise in mathematics education. The researchers provided support and feedback throughout the project and conducted the study on the effectiveness of the initiative. As part of the action research process the teachers gathered evidence from their practice and used this to document and analyse their project activities using the action research cycle of plan, act, observe and reflect. Each of the individual projects culminated in a written research report and showcase presentation to colleagues.

This research evaluation was commissioned to document and explore the implementation of the Euclid Project within and amongst the participating primary and secondary schools aimed at improving the students’ experiences of mathematics teaching and learning during the middle years with the view of improving the transition from secondary to primary school and, in time, overall mathematics achievement. This report provides an evaluation of the Euclid
Project, ‘researching the research’ of the participating teachers. The following section provides some background literature to provide context to the Euclid Project and its evaluation.

**Background**

**Engagement, Mathematics, and Middle Years**

It is believed an increasingly smaller percentage of students in many countries appear to be pursuing the study of mathematics beyond a lower secondary level (Masters, 2016). This choice is seriously influenced by attitudes towards and performance in mathematics, and is significantly shaped by school mathematical experiences (Nardi & Steward, 2003), hence student engagement with mathematics has been of increasing concern amongst mathematics educators (C. Attard, 2014; Everingham, Gyuris, & Connolly, 2017). Disengagement often begins during the primary school years, when children are forming attitudes towards their learning that can last into adulthood. Some of the reasons disengagement occurs relate to the disconnect between school mathematics and students’ lives outside the classroom, and classroom practices that reflect a traditional approach to teaching and learning with a focus on more formal, competitive assessment practices and text book based lessons. Students often struggle to see the relevance of mathematics in their current or future lives (Boaler, 2009), sometimes leading to mathematics anxiety resulting in poorer academic achievement and ultimately influencing decisions about the continuing study of mathematics (Baroody, Rimm-Kaufmann, Larsen, & Curby, 2016; Everingham et al., 2017).

Disengagement with mathematics has the potential to cause problems for students that extend beyond the school years. The reasons students make the decision not to participate are varied. Curriculum relevance, peer influence, transition to secondary school, grouping, teaching styles and assessment are all cited by research as issues of concern in mathematics teaching and learning (Boaler, Wiliam, & Brown, 2000; Clarke, 2003; McGee, Ward, Gibbons, & Harlow, 2003; Patrick, Ryan, & Kaplan, 2007; Walshaw & Anthony, 2007). A dislike for mathematics during the middle years could potentially lead students to rule out a wide range
of career options causing enduring effects on life choices (Anderman & Maehr, 1994; McPhan, Moroney, Pegg, Cooksey, & Lynch, 2008). Although the demand for science, technology, engineering and mathematics (STEM) skills is increasing due to the demands of our increasingly technological society, there may be a future shortage of capable mathematicians due to the decrease of participation in and engagement with mathematics (Organisation for Economic Cooperation and Development, 2006).

Transition to Secondary School

Students about to transition from primary to secondary schooling often have pre-conceived ideas and high expectations of the academic challenges presented by secondary schools. Often students’ perceptions of what is involved at secondary school are distorted and are promoted by parents, older siblings and often primary school teachers. Despite their best intentions, parents and primary teachers are generally unfamiliar with the secondary school environment and curriculum and attempts to prepare primary students for secondary schooling may result in preparing them for an environment that does not exist (Akos & Galassi, 2004; Attard, 2011). This is particularly relevant to the study of mathematics, where students are often prepared for work they perceive to be ‘much harder’ than primary school mathematics (Howard & Johnson, 2004). It is also relevant to the Euclid Project, where collaboration across primary and secondary schools was encouraged.

Difficult transitions to secondary school can lead to disengagement, negative attitudes towards school, reduced self-confidence, and reduced levels of motivation, particularly in the area of mathematics education (Athanasiou, Philippou, Tzekaki, Kaldrimidou, & Sakonidis, 2009). Some of the transition difficulties that impact negatively on students are the disruptions within friendship networks, reducing relatedness to school and classroom, the different structure of the secondary school (larger number of teachers), and a more competitive and norm-referenced environment, resulting in lower engagement.

Such transition issues are not limited to students in Australian schools. McGee et al., (2003) found substantial agreement in international literature that an effect of transition is often a
decline in achievement. Eccles and Wigfield (1993) attribute the decline in students’ attitudes and performance in subjects such as mathematics to changes in students’ concepts of themselves as learners as they get older. In contrast to this belief, Whitley, Lupart, and Beran, (2007) claim secondary teachers often have higher expectations of students when compared to primary school teachers, thus explaining the decline in achievement as a mismatch between teacher expectations and students’ abilities. Related to high expectations of students, one of the issues facing secondary teachers is how much they want to know about their students coming from primary school. Some teachers favour a ‘fresh start' approach as they are often faced with students from a variety of schools, perhaps to the detriment of some students. Research has found this to be particularly the case with mathematics, causing a lack of continuity across the curriculum (Bicknell, Tzekaki, Kaldrimidou, & Sakonidis, 2009).

Another long-term issue of transition identified by McGee et al., (2003) and still continuing to occur, is curriculum continuity and coherence across primary and secondary schools. It was found there are gaps in subject content, differences in teaching and learning practices and inconsistencies in the expectations of students. Current curriculum documents aim to address this and minimise gaps in curriculum by presenting content as a continuum across the grades, with all teachers having access to the content requirements for learners at all stages (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010, NSW Board of Studies, 2012).

Lowered achievement levels could also be explained by the use of more formal, competitive assessment practices that students experience in secondary school. A move away from intrinsic methods of assessment towards a more impersonal, more evaluative, more formal and more competitive environment is another significant factor effecting transition to secondary school.

*Effective pedagogy requires effective assessment, assessment that provides the critical links between what is valued as learning, ways of learning, ways of identifying need and improvement, and perhaps most significantly, ways of bridging school and other communities of practice* (Wyatt-Smith, Cumming, Elkins, & Colbert, 2010 p.320).
It is through our assessment we communicate most clearly to students those learning outcomes we value, yet it is often held that no subject is as associated with its form of assessment as is mathematics (Clarke, 2003). Assessment practices in secondary mathematics often consist of formal methods of assessment such as tests and examinations (Wiliam, 2007), and it is believed that such strategies need as much consideration for renewal as does content and classroom pedagogy. Although much progress has been made in terms of improving mathematics teaching and learning and curriculum, many such improvements have failed due to a mismatch between assessment practices and pedagogy (Bernstein, 1996; Pegg, 2003). It has been suggested that in mathematics, there should not be more assessment, but more appropriate assessment strategies implemented to inform learning and teaching as well as report on progress and achievement (Australian Association of Mathematics Teachers, 2008; Clarke, 2003).

**The Euclid Project**

The following section provides a description of the Euclid Project activities and the project groups that emerged.

**The Action Research Approach**

Action research is an approach commonly used by teachers to improve practice and is particularly useful for bringing about change within a local setting (Cohen, Manion, & Morrison, 2018). It can be used to solve specific problems, to pose problems, or to “embrace areas of interest for development” (McNiff, 2010, as cited in Cohen, Manion, & Morrison, 2018, p. 440). Action research can be conducted by individuals, groups of teachers within a school or network, and alongside other interested parties such as university academics.

The action research approach typically consists of a four step process that, depending on the research and the teachers’ reflections, can become a sequence of cycles (Figure 1). Rather than being focused on researching a problem of education, action research requires practitioners to focus on a problem of practice (Mertler, 2018). During the initial cycle, the
researcher identifies a problem of practice to be addressed. A plan is then formulated and put into action. At each point in the action research cycle the researcher collects evidence to assist in evaluating the success of the research and to assist in the planning of future cycles.

Within the Euclid Project, five distinct action research groups emerged (Table 1). Projects 1 to 3 were collaborations across different schools, and Projects 4 and 5 were each conducted within one school. Project 5 began with two teachers but, due to circumstances, concluded with one participating teacher.

Preparing for Action Research

During the conception phase of the Euclid Project two professional development days were hosted in Canberra by the District Director. The days were attended by the Director, an academic attending as a critical friend and provider of professional learning (who later became the researcher), and invited middle years mathematics (Years 5 – 8) teachers from the Queanbeyan network. The initial day consisted of a professional development session on mathematics pedagogy for Stage 2 and 3 teachers, and two other presentations to promote the sharing of practice amongst schools. The second day included a session on establishing action research and a planning session for the teachers to work in collaboration with colleagues from other schools. At the conclusion of the second day, the teachers were given an opportunity to decide if they wanted to move forward into formal action research groups with the assistance of the researcher, or not. Teachers could still access the expertise of the
researcher regardless of whether they conducted formal action research projects. Five action research groups evolved following the initial two days of professional development (Table 1).

<table>
<thead>
<tr>
<th>Group</th>
<th>Schools</th>
<th>Primary Teachers</th>
<th>Secondary Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooma Public School</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Cooma North Public School</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jindabyne Central School (secondary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monaro High School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Jerrabomberra Public School</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bungendore Public School</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Karabar High School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Queanbeyan East Public School</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Queanbeyan West Public School</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Queanbeyan South Public School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Karabar Distance Education Centre</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Queanbeyan High School</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Euclid Action Research Groups

**Euclid Project Activities**

During the course of 2017, the action research groups committed to participating in a range of activities (Table 2). These were a combination of whole group days in Canberra and visits to each of the project groups by the research team. In between the formal project activities there were informal meetings with the research team conducted electronically via Zoom videoconferencing software.
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term 1</td>
<td>Full day planning workshop (Canberra) for all project participants.</td>
</tr>
<tr>
<td></td>
<td>Content covered:</td>
</tr>
<tr>
<td></td>
<td>• Understanding collaborative action research methodology</td>
</tr>
<tr>
<td></td>
<td>• Identifying the issue to be addressed</td>
</tr>
<tr>
<td></td>
<td>• Using an action research proforma (Appendix 1) to plan your action</td>
</tr>
<tr>
<td></td>
<td>research</td>
</tr>
<tr>
<td></td>
<td>• Posing and refining the research questions</td>
</tr>
<tr>
<td></td>
<td>• Drafting the action research activities</td>
</tr>
<tr>
<td>Term 2</td>
<td>Visits to schools by research team</td>
</tr>
<tr>
<td></td>
<td>• Teachers provided updates on project activities and</td>
</tr>
<tr>
<td></td>
<td>received feedback and advice from research team</td>
</tr>
<tr>
<td>Term 3</td>
<td>Full day workshop (Canberra) for teachers to report progress, seek and</td>
</tr>
<tr>
<td></td>
<td>receive peer feedback and discuss action research evidence and</td>
</tr>
<tr>
<td></td>
<td>evaluation</td>
</tr>
<tr>
<td>Term 4</td>
<td>Visits to school by research team</td>
</tr>
<tr>
<td></td>
<td>• Teachers were provided with feedback and advice from</td>
</tr>
<tr>
<td></td>
<td>research in regard to project reporting and analysis of</td>
</tr>
<tr>
<td></td>
<td>evidence</td>
</tr>
<tr>
<td></td>
<td>Full day dissemination showcase (Canberra)</td>
</tr>
</tbody>
</table>

*Table 2: Project Activities 2017*

During the Term 1 meeting the teachers formed their groups. Three of the groups consisted of teachers from a number of different schools within the same areas. Two groups (Karabar Distance Education Centre and Queanbeyan High School) conducted action research as individual schools. Although the three groups working across a number of schools were working collaboratively to identify research questions that addressed a shared problem or challenge, each of the individual schools within those research groups conducted variations of the research according to the specific needs of their individual school or classroom contexts.
Evaluation Design and Methods

A qualitative, multiple case study approach was undertaken in this research evaluation where each action research group is regarded as one case.

The following research evaluation questions were investigated:

I. Can the implementation of a range of action research projects within and across schools from the same school district promote change in the teaching and learning of middle years mathematics?
   - What are the individual action research projects implemented in the Queanbeyan network of schools?
   - What were the processes and outcomes of those projects?

II. Did students’ perceptions of mathematics change as a result of the action research?

III. What were the teachers’ perceptions of the action research process and projects?

Evaluation Participants

All the teachers who volunteered to participate in action research groups indicated their consent to take part in this research evaluation. A total of 23 teachers (varying in experience from being newly graduated to over 20 years in the classroom, gave consent). Each participating school also had the opportunity to invite students to take part in focus group discussions (5 – 6 students per group) although due to the geographical spread of some of the research group schools, not all schools were represented by students. Focus groups were made up of girls and boys, and where possible represented a diversity of academic abilities.

Ethical Procedures

The research methods employed in this evaluation were approved by Western Sydney University’s Human Research Ethics Committee (approval number: H12050) and the NSW Government’s Department of Education (approval number: SERAP-2017103). All participants
were provided with a plain language information sheet about the research and all provided informed consent to participate.

Data Sources

Data for this evaluation was gathered from the following sources:

*Interviews*: The Director, Public Schools, Queanbeyan Network was interviewed at the start and at the end of the project to determine the overall initiative goals and perceived attainment of those goals.

*Group Interviews (Teachers)*: Teachers in each action research group participated in group interviews at four points throughout the project (once each school term) except in the case of Queanbeyan High School, where one teacher remained on conclusion of the project. In that case, the remaining teacher participated in an individual interview. Group interviews were used due to the collaborative nature of the action research. It is expected that collecting data from the teacher groups rather than individuals would promote rich discussion and data that would also be useful in facilitating the projects as well as evaluating their success. Group interviews were audio-recorded by a research assistant while the Chief Investigator managed the group and provided discussion prompts.

*Focus Groups (Students)*: At least one sample group of students from each project (five to six students) representative of the student population within each individual project was formed to determine students’ beliefs about mathematics education and whether they changed as a result of the action research. Students were selected by their teachers. There was a total of eight student focus groups overall. Focus group discussions were audio-recorded by the research assistant while the Chief Investigator managed the group and provided discussion prompts.
The variety of data sources was intended to provide triangulation and allow the researcher to determine the success of the initiative from three levels; student, teacher and leadership. The following interview topics were used as open-ended prompts for each group of participants:

Director:

*Initial Interview*

- Can you talk about why you instigated this initiative of network-based action research?
- Tell me about the state of mathematics teaching and learning in this network?
- What do you hope to achieve with this initiative?
- What are the things you have done so far to support the teachers in your network to participate in action research projects?

*Final Interview*

- Can you talk about the action research projects that took place in the network?
- What do you perceive to be the effects of the projects in the network in relation to teachers and students?
- Do you consider the projects to have achieved your goal?
- Where to next?

Teachers:

*Term 1 meeting*

- Aims of their project
- What they consider to be the current attitudes and perceptions of their students in relation to mathematics teaching and learning
- Anticipated project activities
- Anticipated project outcomes

*Term 2 meeting*

- Project activities to date
- Changes you have noticed relating to teaching and learning of mathematics
• Perceived changes in students as a result of project activities
• Where to next with project?

**Term 3 meeting**
• Project activities to date
• Changes you have noticed relating to teaching and learning of mathematics
• Perceived changes in students as a result of project activities
• Where to next with project?

**Term 4 meeting**
• Project evaluation
• What are your reactions as a group to the outcomes of the project?
• What are the perceived student reactions to the project?
• Outcomes of the project
• Surprises/unintended outcomes of the project
• Next steps
• Advice to others considering action research projects

**Students:**

**Term 2 meeting**
• Beliefs about mathematics teaching and learning
• Things you would like to improve relating to mathematics education
• Things you enjoy/don’t enjoy about mathematics teaching and learning

**Term 4 meeting**
Students will be prompted to discuss the following:
• Changes you have noticed relating to teaching and learning of mathematics as a result of the project
• Beliefs about mathematics teaching and learning
• Advice to teachers relating to teaching of mathematics and the project itself
Data Collection

Due to the diversity of the groups involved in the Euclid Project, not all participants were able to participate in all aspects of data collection. The following table details the data collected from each group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Group Interviews</th>
<th>Student Focus Groups</th>
<th>Showcase Presentation</th>
<th>Submission of Research Report</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Term 1</td>
<td>Term 2</td>
<td>Term 3</td>
<td>Term 4</td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3: Group Participation in Data Collection Activities

Data Analysis

Each research group was treated as an individual case. Data was audio-recorded and transcribed verbatim. Data from each group was analysed separately to identify emerging themes in response to the evaluation questions. A cross-case analysis was then conducted to seek common themes across the five research groups.

The findings from this evaluation will first be presented as five separate case studies. Within each of these cases, the following questions are addressed:

- What are the individual action research projects implemented in the Queanbeyan network of schools?
- What were the processes and outcomes of those projects?
• Did students’ perceptions of mathematics change as a result of the action research?
• What were the teachers’ perceptions of the action research process and projects?

Following this, emerging themes across the cases will be discussed and the full set of evaluation questions will be addressed from a whole project perspective. The report will conclude with a set of recommendations that arise from the research.
GROUP 1: COOMA/JINDABYNE/MONARO

Group 1 consisted of teachers from four schools. There were in close proximity to each other in Cooma, and the fourth was located at Jindabyne. Five teachers from two secondary schools, Monaro High School and Jindabyne Central School (secondary teacher), and two primary schools, Cooma Public School and Cooma North Public School were involved. The teachers’ experience ranged from early career to late career (20+ years). During the initial stages of the Euclid Project the teachers in this group discussed differences and commonalities in relation to their students’ mathematics outcomes across the schools. Each of the schools identified a common area of concern that was focused upon issues relating to problem solving. In the secondary classrooms, a concern over students’ abilities to comprehend the language embedded within mathematical problems, followed by the actual mathematics required, was identified as an area to address through action research. Similarly, in the primary classrooms a move away from a traditional, mathematical content focused practice to a problem solving approach was expressed as a goal of this action research. Through a process of discussion and negotiation, the following research question and sub-questions were articulated:

How does explicitly teaching the Working Mathematically strand improve student numeracy outcomes?

- How does focusing on literacy improve numeracy outcomes? (Jindabyne CS)
- How does having a variety of problem solving strategies improve self-confidence in mathematics? (Cooma North PS)
- How does flipping the learning so students come up with their own strategies improve problem solving? (Cooma North PS)
- By using a journal that is commonplace in all Snowy Mountain schools, do students find a sense of commonality and confidence when transitioning from primary to high school?
- By utilising more problem solving experiences, enabling more collaborative group work, increase students’ sense of fun in mathematics learning? (Monaro HS)
Although it is not typical practice to have such a lengthy list of sub-questions, this is a reflection of the diversity of the schools, their teachers, and their particular needs within the overarching research question. Not all sub-questions were addressed by all teachers/schools.

**Group 1: Processes and Outcomes**

As each teacher/school in this Project Group adapted the main research question to suit their individual contextual needs, the action research processes will be discussed separately before a combined discussion of the outcomes of the overarching research.

**Jindabyne**

The participating teacher at Jindabyne CS was also the Head Teacher of mathematics. The students at this school had difficulty understanding and interpreting mathematical problems, and so the prime focus of this action research was to assist students in developing skills to understand the language of mathematics and the process of problem solving. Although the teacher here was not teaching a middle years class, her leadership role required her to work with the teachers across the school to develop strategies that would assist the students, which in itself was an important aspect of the action research at this school. The major focus of the research was the design of a Problem Solving Mat. The mat required students, in a step by step approach, to break down the word problems and translate the written words into the mathematics required to solve the problem. Following this, students were required to reflect on and evaluate their work.

The research challenge at this school was aimed at both the students and their teachers, who had to consider how to balance teaching the mathematical content in a traditional way, compared to taking a more holistic approach to mathematics teaching through the Working Mathematically processes. Although she encountered some resistance at the start, teachers did eventually...

“...even though they (the other teachers) are concerned that it is going to take time from the curriculum...all the teachers are really positive about it because they are aware that if we can get a format...it is going to help along the track”
become enthusiastic about the new approach, “…essentially it was just fear. Fear of what to
do, fear it wouldn’t work. But they are quite positive about it now and they are having good
lessons”.

Monaro

There were three teachers from Monaro High School at the start of the Euclid Project,
however one teacher withdrew as he was no longer required to teach mathematics due to
timetabling changes. The two remaining teachers were both in the early stages of their
careers and had been teaching without the supervision of a head teacher over the course of
the Euclid Project due to staffing issues. They also commented that there were significant
differences in teaching styles within the mathematics faculty that resulted in little support
from colleagues who were not involved in the action research.

The central goal of the two teachers’ action research was to improve
problem-solving skills in Stage 4 in order to improve learning outcomes,
with a particular focus on students who at the time were considered by the
teachers to be ‘under-performing’. The effectiveness of the research would
eventually be measured by students’ NAPLAN results. More specifically, the
teachers wanted the students to learn a process for problem solving that
would allow them to apply the strategies to any mathematical problems,
regardless of the topic or content involved. This move away from a topic
driven approach would promote the Working Mathematically strand from
the curriculum.

At the start of the action research the teachers at Monaro HS administered a survey to gain
some understanding of students’ attitudes towards mathematics and towards problem
solving in particular. The results indicated some negative attitudes towards mathematics and
although the students rated themselves as being reasonably confident with problem solving,
clear improvements were noted by the teachers in the results of the final survey administered
following the problem solving intervention that was implemented as part of the teachers’ action research. The teachers’ analysis of the survey results were included in their report.

The changes implemented by the teachers included the use of a student journal to document and reflect on their problem solving work. The teachers at Monaro HS used the same Problem Solving Mat that was implemented at Jindabyne CS, in additional to the journal. Problem solving and journal writing did not become a part of the daily routine. Rather, it was timetabled to occur once a fortnight, which did not indicate a change in teacher practice, the goal of action research. This could be attributed to the lack of support provided to the teachers combined with the relative inexperience in the classroom along with the desire to deep up with the grade’s scope and sequence document and schedule of topic assessments.

**Cooma North**

One Year 6 teacher from Cooma North Public School participated in the Euclid Project. Cooma North is located directly across the road from Monaro HS, and many of its students make their secondary schooling transition there. Although the only teacher from the school actively involved in the Euclid Project, the teacher at Cooma North worked with the other teachers in Stage 3 at the school throughout the action research so that a consistent approach to teaching mathematics occurred throughout the Stage 3 classes.

During the course of the Euclid Project the teachers at Cooma North also participated in a number of other projects and these were undertaken in conjunction with their action research. Their focus, as with the other schools, was on developing the students’ problem solving strategies, and there was close collaboration with the colleagues at Monaro HS and Cooma PS, with school visits and observations occurring early in the year to promote a shared understanding of each school’s context.

The main ‘action’ from the research at Cooma North was the introduction of a Euclid Journal. This journal was a dedicated booklet where students recorded their mathematical problem solving work. The teacher at Cooma North decided he would introduce individual problem
solving strategies to students to assist them in building a repertoire of skills in preparation for NAPLAN testing and in the hope that this would equip them for success in secondary school mathematics. This teaching strategy was replicated in each of the Stage 3 classes at the school, although each teacher adapted his or her own variation of how and when it was incorporated into mathematics lessons.

Cooma

At Cooma Public School the focus again was on problem solving, comprehension and reflection. Unfortunately, approximately half way through his action research, this teacher was placed in a new class, with new students. This caused some slight disruption to the action research. Although on a different class, the focus at the school on problem solving continued across the school under the mentorship of this teacher.

Similarly to Jindabyne CS, the research at Cooma PS also focused on teacher development as a way to improve students’ academic outcomes. The action research included an initial survey of teachers’ current practices, then a facilitation of the use of problem solving and assessment of student learning. As the school was also involved in another numeracy project, the two projects were complementary and many of the activities undertaken at the school were done so under the combined two projects.

Although the Euclid Project was intended to have a primary-secondary transition focus, the teachers at Cooma identified that change needed to occur prior to Stage 3 and so the whole school approach to problem solving was facilitated. The teachers recognised the importance of problem solving from the early years to minimise issues occurring in the later years.
Overall, the group experienced positive outcomes from their combined action research. It is arguable that this group’s success can partially be attributed to the amount of collaboration, the shared goals and the inclusion of other colleagues within the individual action research. Teacher engagement was addressed alongside student engagement, and ultimately this is what is more likely to lead to improvements in student academic outcomes.

At Jindabyne CS, the teacher reported success from both student and teacher perspective. Prior to the research it had typically taken two years to convince students to record their solutions to mathematical problems. An aim within the research was to provide students with the skills to do this from Year 7, and eventually from the primary years. Expanding the action research and the problem solving work into the primary classrooms (located at the same location as the secondary) is a future goal that will assist in a smoother transition to secondary through a continuation of mathematics pedagogy utilising the problem solving mats. Some efforts were made to involve the primary teachers at Jindabyne and after some initial resistance, discussions with individual teachers began to result in some progress.

Although initially the students at Jindabyne did not enjoy filling out the problem solving mat, over time improvements were noted in their documentation and their ability to articulate their learning and challenges. More importantly, there were changes in teachers’ practices throughout the secondary school from Year 7 to Year 12. Students had begun thinking about the process to solve problems and the intention was that the research would continue and students’ skills would continue to develop. NAPLAN results for 2017 indicated individual student growth while any negative growth had declined. Anecdotal evidence from the teacher indicated the Problem Solving Mat assisted students who had comprehension

“It sparked an interest and motivation in the AP that I've been having meetings with. She’s quite excited about teaching problem solving now.”
challenges and increased the students’ perceptions of the relevance of mathematics, thus improving student engagement.

The Monaro teachers achieved some success and had a sense that students were much more engaged when participating in mathematical problem solving activities. There were benefits for the teachers, particularly as they were both early in their careers. The more experienced teacher discussed how her lessons had become more interactive and she now made more efforts to present content in different formats to enable her to cater to the diversity of needs in her classroom. However, the two teachers did experience some challenges. Timetabling changes resulted in a change of class in Term 2 for one of the teachers and they both felt that teaching through a problem solving approach did not allow them time enough to cover content. This perception is common due to the more traditional approach in secondary mathematics classrooms where content is taught in a certain order for a certain period of time. A problem solving approach tends disrupt this practice and requires teachers to reconsider the Working Mathematically processes as a priority over teaching content in isolation.

At Cooma North Public School, positive results were reported by the teacher despite challenges caused by limited time and resources. Most notably was the discussion about teacher change across the school: “we’ve had a complete turnaround in teacher mindset here at Cooma North”. Significant changes to teaching practices were discussed, with an important shift from a traditional, content based approach to teaching mathematics to a problem solving focussed approach that encouraged mathematical thinking. Prior to the action research at Cooma North, teaching was focused on computation and not embedded within contexts. A traditional approach that supported instrumental understanding (teaching rules) as opposed to relational (conceptual) understanding is not conducive to academic success or student engagement. The processes of Working Mathematically had not been addressed specifically at the school although it has featured in NSW

“\textit{I think we missed an opportunity to measure the change in teachers’ attitudes because at our school that is our biggest success story.}”
\textit{(Cooma Nth)}
mathematics curriculum documents since 2004. Teachers were now recognising the importance of Working Mathematically and noticing that students were more engaged when they were given tasks that accessed the components of the Working Mathematically strand.

Despite unforeseen challenges due to staffing changes, there were some noticeable improvements observed at Cooma Public School. Improvements were observed in student reflection and an increase in the use of meta language in mathematics. A heavier emphasis on student group work in mathematics revealed some benefits of having heterogeneous groupings that led to peer mentoring amongst students. The teachers at Cooma PS found this practice to be beneficial for lower achieving students. Similarly to the other schools in this group, collaboration amongst staff also improved.

**Group 1: Students’ perceptions of mathematics**

Data gathered from two groups of students (Monaro HS and Cooma North PS) is discussed here. Initially the focus group students at Monaro HS provided very typical reactions when asked how they felt about mathematics. Although they didn’t indicate a passion for mathematics, they suggested that it could be made more fun through activities such as problem solving as opposed to repetitive work, implying that their prior experience with mathematics consisted of a drill and practice approach. The students also compared the mathematics they were experiencing in secondary to what they experienced in primary, claiming mathematics was more fun in primary school due to the interactive nature of the classroom activities. At the end of the project the students from Monaro HS discussed how their work on problem solving had been of benefit, helping them to break down the problems into more manageable parts, making mathematics easier. However, they did not appear to have altered their perceptions of mathematics. One student synthesised the group’s comments with this statement: “I probably
wouldn’t choose to do it because I don’t enjoy maths that much. But if I had to do it I would keep going with it.”

The primary students in this project had similar views about mathematics when first interviewed, indicating they sometimes enjoyed it, and sometimes disliked it:

I just like doing it and especially when you do it with friends and stuff, you can talk about it. I enjoy the challenge and I think it is pretty fun to do problem solving. An then there’s parts I don’t like. When you are doing like a big test, just all answers and like fractions – I don’t like fractions (Student from Cooma Nth PS).

When talking about the mathematics they did not enjoy, the students listed concepts such as division, fractions and learning the multiplication facts. Overall, they did not appear to be disengaged with mathematics.

During their final focus group discussions and following a focus on problem solving during the previous two terms, the students at Cooma North PS indicated the mathematics work had become more challenging, and they specifically mentioned their ‘Euclid Challenges’. They went on to indicate that perhaps the work was getting harder because the students were getting better at mathematics and this was a good thing: “Because I’ve been getting better at it it’s gotten a little bit harder instead of easier.” The students also believed that the explanations from their teacher had improved, and this is likely because of the specific focus on problem solving strategies. The students’ comments indicated they felt they were scaffolded more by their exposure to the range of problem solving strategies, leading to more positive attitudes towards mathematics.
Group 1: Teachers’ perceptions of the action research process

Perceptions of the research and its results at each of the schools were mostly positive, and this is evidenced by a clear desire for the students from Cooma North to continue with their journal work during their transition to Monaro HS in order to maintain the confidence they had built in regard to problem solving. Likewise, the teachers at Monaro were hoping that the journal work they had begun with their students would be maintained. At Jindabyne CS, despite being located under the same roof, there was still some divide between the primary and secondary teachers. However, although progress had been slow, there were some indications that the action research had begun to narrow the divide between primary and secondary and it was felt that this would eventually result in “reciprocal benefits”.

In terms of the process of collaborative action research, there was consensus amongst the group that having a colleague to work with within the school was beneficial. At Cooma North, a school with only one participating teacher it had been a struggle to enthuse colleagues. Although three out of the four schools in this group were located within close proximity of each other, the teachers still found it a logistical challenge in terms of working collaboratively across schools due to the range of competing demands that each teacher was experiencing. The primary teachers expressed a desire to teach in the high school and vice versa. The teachers did enjoy working with Euclid Project but were also aware of what one teacher termed ‘project fatigue’, where tensions were felt due to the number of projects schools are involved in at any one time.

“\textit{It was good to see what other schools are doing. I loved the networking with neighbouring schools and sharing of ideas.}”

Group 1: Next Steps

Each of the teachers in this group hoped to continue with their action research beyond the Euclid Project. For example, the next steps at Cooma North had already begun at the time of the final data collection, with the development of a collection of resources based around
mathematical thinking and linked to specific mathematics curriculum content areas. It was hoped that this collection would enable teachers to have access to a range of resources that would assist in maintaining the momentum that had built as a result of the action research, moving towards a more contextual approach to teaching mathematics. In terms of continuing action research, each of the teachers in Group 1 indicated a desire to continue working as a group and ensuring ‘new practices’ continued to develop.
At the beginning of the Euclid Project Group 2 consisted of six teachers from three different schools: Jerrabomberra Public School (two teachers), Bungendore Public School (one teacher), and Karabar High School (three teachers). Although their concerns differed, the teachers from Jerrabomberra and Karabar decided to work together as a group as they are located within close proximity to each other, and each year several students graduating from Jerrabomberra enrol at Karabar High School. It was hoped that by gaining a better understanding of each school’s context, these teachers could work towards making the transition from primary to secondary schooling a better experience for students in relation to mathematics. The teacher from Bungendore felt her students’ needs aligned well with those of Jerrabomberra’s students, however took extended leave during the first part of the year and consequently did not participate in any of the data collection activities. Although some work on improving mathematics was conducted at Bungendore Public School under the umbrella of the Euclid Project, details and results were presented at the showcase and detailed in the group’s final report but are not included in this report.

An area of concern identified by the teachers from Jerrabomberra was student disengagement and a resistance to taking risks within mathematics lessons. The teachers were also aware that students appeared to be learning concepts in a very shallow manner and many held a very narrow view of mathematics. At Karabar, the teachers felt that although their students appeared engaged at the start of Year 7, in the past they typically became less engaged as they have progressed through the first year of secondary school. Evidence of student disengagement on commencement of the action research was poor classroom behaviour, a decline in submissions of homework tasks and many negative student comments about mathematics.

“We’re looking at rich tasks to...enrich their learning and to take away the focus of pen and paper assessment... and incorporate some others ways of assessing learning.”
The overarching research question shared by each of the schools in Group 2 was:

**How will a focus on deeper understanding influence student engagement?**

At Jerrabomberra, the research was informed by the following sub-questions:

- What is the influence of using rich and relevant tasks on student learning and engagement?
- How are student conceptual understandings influenced by explicitly make connections between prior and current learning?

At Karabar, the following sub-questions were posed:

- What is the effect of using rich and relevant in-class tasks on student learning and engagement?
- What is the effect of using a rich and relevant take-home task on student engagement?
- Will an increase in student engagement lead to an increase in student understanding and results?

**Group 2: Processes and outcomes**

As the focus of each school’s research was slightly different, their processes and outcomes will be discussed separately.

**Jerrabomberra Public School**

At the beginning of their research the teachers at Jerrabomberra decided they would try a range of strategies to improve their students’ engagement and improve their conceptual understanding. One of the major issues they were attempting to address was the shallow learning that appeared to be taking place. This shallow learning was evident when students were unable to generalise their understandings across mathematical topics. In addition, students did poorly on assessments of content when that content had been taught several
weeks prior: “...you teach the something, assess them three or four weeks later, and they wouldn’t have an understanding of what you had taught them so they weren’t transferring that.” Assessment tasks were also identified as a related issue as the teachers at the school relied heavily on traditional pen and paper tests. Arguably, these tests, combined with a scope and sequence document that presented the curriculum content as isolated, individual topics were contributing factors to the students’ disengagement and low achievement levels.

The initial action of the Jerrabomberra team was to conduct a student survey of attitudes towards mathematics and then review the Stage 3 scope and sequence document to ensure there were links made across the range of mathematical concepts. This included reconceptualising the curriculum as a set of big ideas as opposed to a list of individual and unrelated topics. By doing this, the teachers were able to introduce rich tasks, problem solving, and mathematical investigation, which was a significant move away from the typical text book and worksheet style of lesson previously experienced at the school. To support this new strategy, the teachers also introduced a mathematics journal to promote student reflection and encourage students to see connections within their learning.

In addition to conducting action research within the classroom, the Jerrabomberra team decided to add another layer of research by also focusing on their teaching colleagues. A survey was administered to the teaching staff to determine their perceptions and confidence relating to the teaching of mathematics and the amount of time allocated for mathematics lessons within each individual teacher’s weekly timetable. In effect, they were investigating both teacher and student engagement at the school. The results of the teacher survey then led to some internal professional development to lift the status of mathematics across the school:

I would like to see both teachers and students more engaged in mathematics. And when I say teachers, I strongly believe – my survey is starting to show this – that many teachers have maths on their timetable ... they avoid it at all costs and find anything that they can do to not do maths ... something way more important has interrupted their schedule. And so, I would like to
see teacher more engaged in maths and then as a result, students would be more engaged (Year 6 teacher, Jerrabomberra).

Overall, the action research that had begun at Jerrabomberra Public School appeared to have been a success with the Stage 3 students and with the whole school staff, as indicated in the interview excerpt below:

...we have finalised the survey of the students and the staff and we have presented to staff ... so we get a whole staff thing where we talked about teacher engagement and then I gave them some ideas about fractions and how to teach fractions and we are finishing that up in a week or two weeks or something where I am just going to look at different activities they can do for teaching within the classroom I have definitely started using a lot more enquire based learning and getting the students involved in what they do and trying to do problem based sort of teaching of skills to try and get the students to understand that their maths is valuable and useful and that they can use it across the board. And I have definitely noticed a change in the students in terms of sometimes their excitement ... some of them, not all of them, but there has definitely been a bit more enthusiasm.

Karabar High School

The students at Karabar High School were disengaged with mathematics. According to their teachers, they "tolerate it and loathe it". The teachers discussed how cultural norms and generations of Karabar families perceiving themselves as being bad at mathematics was partially to blame for the current crisis. However, the teachers also acknowledged that they had the capacity to adapt and improve their own practices to promote more positive student engagement.

Prior to their action research, the Year 7 teachers at Karabar High School had attempted to improve or maintain student engagement for transitioning students by beginning the year with Stage 4 content rather than their usual practice of spending some time revising Stage 3
content. As part of their action research, they worked collaboratively to make the content more engaging through a more hands-on approach and with the integration of digital technology:

For example, when introducing the properties of quadrilaterals, instead of a teacher directed lesson, students completed an activity where they cut out different types of quadrilaterals and from a given list, they identified the properties of each quadrilateral by measuring, comparing and discussing (Group Report).

In addition to planning lessons that incorporated a combination of manipulative and digital technologies, the teachers at Karabar HS gathered student feedback to inform their future practice. The teachers also used this feedback as a tool to promote student reflection.

Group Outcomes

Overall the research outcomes of Group 1 were positive – changes in practice were beginning to emerge. However, there was some inconsistency in implementing some of the changes amongst the teachers at Karabar HS and this may have been caused by a number of factors that include a range in teaching experience, confidence in teaching Year 7 curriculum content and a willingness to trial a new practice. Commonalities between the two schools continued to emerge through the project and one of the best outcomes for this group of teachers was the collaboration between primary and secondary teachers that resulted in the reciprocal sharing of ideas. In terms of improvements in student engagement and learning, the teachers at Jerrabomberra perceived a definite shift in their students’ attitudes towards mathematics. At Karabar, changes were less noticeable amongst the students, however the teachers had become more reflective as practitioners and more open to developing their practices to adapt to student needs.

“I have been in education in Queanbeyan for 15 or 16 years and a lot of those old barriers are breaking down which is really lovely to see.”
Group 2: Students’ perceptions of mathematics

At each school the teachers were asked by the research team to select five to six students for participation in a focus group from those who had returned signed consent forms. Where possible, the groups were to be comprised of a representative sample of students in terms of gender, ability and attitude towards mathematics. Rather than a group of students with a range of abilities and attitudes, the student group from Jerrabomberra was comprised of students who held quite negative attitudes towards mathematics at the start of the action research. The students discussed their dislike of mathematics with statements such as: “I absolutely hate it”, “I just don’t like maths”, and “I can do the questions but I just don’t like it”.

It appeared that the students in this group were willing to tolerate mathematics but could not envision themselves experiencing enjoyment when learning mathematics. The students discussed their fear of asking questions in class to avoid being embarrassed in front of their peers. They were very aware that there were some students who could ‘do’ mathematics, and others, like themselves, who couldn’t. They also indicated that their mathematics mostly consisted of worksheet based lessons and that their teacher/s regularly provided extra assistance to students who needed extra help during their lessons.

The focus group at Karabar HS was derived from only one of the participating teachers’ classrooms. The head teacher, who was participating in the Euclid Project, had identified that this teacher may need additional support as it was his first time teaching Year 7 mathematics and this was the justification provided for the selection of this group of students. Ideally, a range of students from across the classes would have provided more balanced representation of the general perceptions of mathematics.
The Karabar HS focus group appeared to have similar dispositions towards mathematics as their primary counterparts at Jerrabomberra. At their first group discussion the students discussed the importance of having a teacher who could explain things well: “...he is good at maths, but he is not good at teaching it” and “…it is challenging most of the time...when the teacher doesn’t explain things the way you want it to be”. The students also compared their experiences in primary and secondary, indicating a drop in their engagement levels and aligning with their teacher’s beliefs that this is a typical occurrence.

At their final focus group, the students from Jerrabomberra showed evidence of a shift in how they perceived mathematics. Although they were still somewhat hesitant to claim they ‘love’ mathematics, they spoke about how the types of activities had changed and how mathematics had become fun, indicating improved engagement. The students spoke about how they now participated in more tasks that were collaborative and how this was helping them to “get it more”.

At Karabar, changes in engagement were less noticeable, with students continuing to display negative attitudes to mathematics. However, there was discussion about the introduction of a more hands-on approach, and students commented on how they found this preferable to text book work. The students also spoke about behaviour issues within the classroom, indicating their teacher often yelled in class. They also expressed a desire for a “teacher who understands where students are struggling”.

Group 2: Teachers’ perceptions of the action research process

Overall, the teachers in Group 1 felt that the process of action research was of benefit to their practice, providing them with an opportunity to reflect. In particular, it assisted them in developing collaboration across schools that would eventually benefit students in their transition from primary to secondary mathematics. The Karabar teachers talked about the challenge of timetabling to ensure participating staff are able to collaborate. They also
suggested that it was important to make small changes in practice that can be built upon during future action research cycles.

The depth of reflection that occurred amongst the teachers varied as did the levels of success in terms of the action research changing practice. However, the following teacher comment implies that for one teacher, the action research process would continue beyond the Euclid Project:

*I would say that is what has been good about it because it actually has led to a change of practice which doesn’t necessarily happen with other types of professional development. And it has been better – having expert advice from you has been useful because it has helped to give us direction and to know that also the changes we are making might actually have some value... it gives you more confidence to make the change too, which we might not have had if we had just done the professional development.*

**Group 2: Next Steps**

The two groups of teachers from Jerrabomberra and Karabar indicated they would continue collaborating beyond the Euclid Project as they found the exchange of ideas valuable. At Karabar, the teachers expressed a desire for action research to be taken up more broadly across the mathematics faculty and intended to provide professional development to their colleagues who had not participated in the Euclid Project.

At Jerrabomberra, the teachers had already begun working across the school and the sustainability of their action research seemed assured, with this comment synthesising the success of their work:

*...the fact that now teachers are seeing that as a good thing that I can come and team teach Maths with them and asking a lot of advice on what can I do for this, I am having trouble with this group, what can I do? So, I think that is where perhaps the teacher engagement across the school is starting to improve.*
GROUP 3: QUEANBEYAN EAST/SOUTH/WEST

This research group consisted of five teachers from three primary schools in Queanbeyan. They named themselves ‘The Compass Team’ as their schools were Queanbeyan East, Queanbeyan South and Queanbeyan West Public Schools. The teachers had not collaborated prior to their involvement in the Euclid Project. During their initial planning meetings, the teachers were originally focused on improving their students’ understanding of fraction concepts, as this is traditionally a difficult topic for students to understand. However, as they progressed through the action research cycle, it became clear that a broader focus was required, and the following research question was articulated:

How can we adapt pedagogical approaches to assist students to communicate and demonstrate their understanding in mathematics?

Group 3: Processes and outcomes

On commencement of the research the teachers in this group conducted a survey of student attitudes towards mathematics. This data was intended to inform the direction of the action research and this is how a focus on fraction concepts emerged. Survey results also indicated that students would prefer more ‘one-on-one time’ with their teacher, that is, the establishment of deeper pedagogical relationships, implying that current practice was not differentiated enough to suit a diversity of student abilities. As well as focusing on fractions, the teachers also attempted to implement new teaching strategies that included the use of small ability groups and student choice. However, these strategies proved to be problematic and revealed unexpected student needs in relation to their comprehension of mathematical problem solving tasks. After consultation with the researcher, the team shifted their focus a second phase in which they restructured their mathematics teaching to include more time on mathematical problem solving and reflection to enhance mathematical comprehension and communication.
One of the major outcomes of the action research for this group of teachers is that they became more responsive to their students’ needs. This led to them changing the way they planned mathematics teaching and learning experiences to a more flexible, student-centred approach. An important aspect of the new responsive approach was a shift of teaching focus from mathematical content to mathematical processes. The Working Mathematically components of the NSW Syllabus (Board of Studies NSW, 2012) consist of problem solving, reasoning, fluency, understanding and communicating.

The students noticed the difference in the teaching and at Queanbeyan East Public School. They appeared to become more confident in seeking assistance from the teacher rather than sitting quietly and failing to understand the mathematical concepts. “The children are just coming forward and saying they are not understanding what we are doing”. At Queanbeyan West, ‘Problem Solving Friday’ was implemented so the students were aware that each Friday they would engage in problem solving and reasoning via written reflections. Increased student engagement at this school was evident when students began requesting Problem Solving Fridays instead of their regular mathematics lessons on other days of the week. The shift to problem solving not only improved the students’ engagement with mathematics, it also influenced the engagement of the teachers in terms of their teaching of mathematics. For example, at Queanbeyan West, the teacher realised the value of teaching through the Working Mathematically strand alongside the content strands: “Overall the problem solving is going to get them a lot further than that one aspect of maths...especially when they go to high school”.

The focus on Working Mathematically also had some impact at Queanbeyan South, in the Opportunity Class (OC). In this class students were already confident in mathematics prior to the teacher’s participation in the Euclid Project. However, they did experience a common issue in gifted and talented education where the students find it difficult to cope with making mistakes. The result of the action research and an emphasis on process was that the students

“My program seems to be more of a work in progress now”
in the OC class became more accepting of mistakes and improved their mathematical reasoning and communication skills.

**Group 3: Students’ perceptions of mathematics**

During the first round of focus group discussions the student groups did not necessarily indicate disengagement with mathematics. However, apart from the OC students at Queanbeyan East Public Schools, they did not appear enthusiastic about their mathematics learning. The Queanbeyan East children were able to clearly articulate why mathematics is important, and they discussed their preferences for interactive, hands-on learning experiences and a desire to have fun while learning. The desire for ‘fun’ in mathematics lessons is common amongst students of this age and previous research (Attard, 2014) has revealed that students consider lessons to be fun when they have been challenged, have had high levels of interaction with mathematics, resources, peers and the teacher, and have felt a sense of achievement. This is opposed to lessons where there is little interaction and the mathematics has no immediate relevance to students’ lives.

The students from Queanbeyan East and Queanbeyan West described their typical lessons as being routinely text-book based: “...we do the text book and then she explains it on the board” and discussed how mathematics can sometimes be fun but also a little stressful when they can’t complete their work within the allocated lesson time. This stress is of some concern when considering these students would be entering secondary schooling in the following year, where teachers often work on strict timelines due to the ways they plan their scope and sequence documents, and student stress is often increased as a result.

When the student focus groups were conducted following two terms of action research it was clear that the changes implemented by the teachers had made a difference to how the students were engaged with mathematics. At Queanbeyan South, the OC students noticed less emphasis on the text book and much more interaction with the teachers. They felt they had more help from the teacher and the teacher had a greater understanding of their individual learning needs. This indicates stronger pedagogical relationship between the
teacher and her students, which is a critical foundation for sustained student engagement. This group of students were asked if they had advice for teachers of mathematics, and this comment is representative of the group’s sentiments: “...do more interacting with their students instead of just handing them a textbook and saying ‘here is your maths today and this is what we are doing, so get on with it’ and just do something else”. Implies there may be times when the students feel the teacher is not attending to their needs. The students also indicated a desire to work in groups rather than individually.

Due to change of class for the teacher at Queanbeyan West, students from that school were unable to participate in the second focus group discussion. However, the students from Queanbeyan South noticed significant changes in the way mathematics was now taught at their school. The children were clearly more engaged, talking about how their lessons consisting of more group work (as opposed to textbook work) and fun activities, “Kids have been more positive towards maths because we are doing more fun activities with it.” The students discussed their participation in a mathematical investigation that was based on a real-life scenario and a mathematics quiz called ‘Ninja Maths’ where they could progress from one level to another and also receive extrinsic rewards from the teacher’s prize box. These activities appeared to provide variety and motivation for students. More importantly, they felt they were progressing academically, and this student’s comment synthesised the sentiments of the group: “I noticed that everyone has been more interested in it and that everyone’s been getting a lot better at it”.

Group 3: Teachers’ perceptions of the action research process

This group of teachers were overwhelmingly positive about the benefits of action research to their practices and the resulting influence the changes to their practices had on their students’
experiences with mathematics. One teacher commented: “It has gone from me being in control of the mathematics to them now being in control of the mathematics and they are requesting more of it”. The opportunity to collaborate with colleagues from other schools was highly valued by these teachers, who discussed how prior to the project they had ‘talked about each other’, yet this had now changed to ‘talking to each other’, culminating in a mutual professional respect that had not existed prior to the Euclid Project. The teachers here had begun to develop a community of practice with shared beliefs and understandings of mathematics pedagogy: “I think it has brought us together to discuss the ways that we are teaching and share ideas”.

Although the ‘Compass Group’ was successful, their work was not without its challenges. The teachers appreciated that there was a level of accountability due to the involvement of university researchers and project deadlines to meet, and this did appear to add some stress to their workloads. However, they did agree that having an external critical friend encouraged them to stay on track and not be distracted: “I feel more accountable...not accountable to just myself and my class but accountable to these ladies as well”.

Working collaboratively across three schools made the logistics of meetings challenging and this meant the teachers had to conduct their meetings after school hours, adding an additional burden to their already busy professional lives. Despite the challenges, the teachers did comment on the value of action research when compared to more traditional professional development opportunities that usually involve one-day workshop or seminars with little follow up and little effect on teaching and learning.

**Group 3: Next Steps**

The participating teachers from Group 3 all expressed a desire to continue as action researchers. At Queanbeyan South, the participating teachers were planning a presentation...
of their research and its results to the school staff and they also indicated they would like to include other teachers in action research to promote further collegiality. The teachers also indicated that they would like more interaction with the neighbouring secondary schools. The Euclid Project had provided some opportunities for conversations to occur with the secondary school mathematics teachers, so relationships and shared understandings had begun to develop. This resulted in the emergence of commonalities amongst the teaching practice in the primary and secondary school settings.
The three secondary mathematics teachers from Karabar Distance Education Centre each had many years of teaching experience within a range of school contexts. The unique challenge of working in distance education includes teaching students who are enrolled for a broad range of reasons, including some who are disenfranchised from traditional schooling. Working at a distance is already difficult in terms of student engagement, where the development of pedagogical relationships forms a critical foundation for sustained engagement with mathematics. On commencement of the Euclid Project and in the initial stages of planning their action research, the teachers at Karabar DEC discussed how several of their students used avoidance strategies that resulted in little or no work being submitted. In fact, many students avoided all contact with their mathematics teachers which made learning difficult at best. Teaching strategies were implemented to suit individual learners, and although the teachers made themselves available for students, levels of student access differed significantly amongst students. It should be noted that no data was collected from the students in this group due to the challenging nature of this distance education context.

The teachers devised the following research question and sub-questions in an attempt to identify strategies that would improve student engagement:

**How does storytelling influence engagement in Mathematics?**

1. *Will this build interest, enthusiasm and confidence in Mathematics?*
2. *Can this help build pedagogical relationships?*

“Some students might call up once a week and they might either have a 20 minute lesson with us or they might just call up when they have a problem. And we might have say a Skype lesson with them where they have a document camera and they can view something. Some students might call up two or three times a day... but it might only be for two or three minutes each time.”
Group 4: Processes and Outcomes

Prior to beginning their action research, the teachers at Karabar DEC had already begun experimenting with the use of narrative to engage their students. One of the teachers had created some short video animations that embedded mathematical concepts into stories. These videos were hosted on YouTube. The purpose of the videos was to assist learners who were struggling with mathematical concepts and to improve students’ affective engagement with mathematics, encouraging more positive attitudes. The opportunity to participate in action research allowed the teachers to further investigate whether the use of video narratives would enhance their students’ engagement with mathematics and improve their understanding of the specific concepts.

During the course of the year, more video narratives were created. However, it was a challenge for the teachers to get students to view the videos. Part of this challenge may have been due to the fact that the videos were created for students who were not being taught by the three teachers conducting the action research. The videos were aimed at Year 7 and 8 students who were essentially taught by someone else. The only method used to disseminate the videos was by word of mouth, which meant only those students who made contact with their teachers knew that the videos existed. In other words, the least engaged students were most likely to be unaware of the videos. Although strategies for embedding the videos into the regular course content were discussed during the meetings with the research team, this was not something that could be enacted at that time. The course booklets sent out to students were prepared well in advance of the school terms, making it difficult to change the content until the following school year.

The teachers eventually sent emails to specific students with links to videos in the hope that they could get some students to engage with them and provide feedback. This had limited success, with few responses from students. However, one student did provide feedback during the year, indicating the videos assisted her in understanding the mathematical content.
During their final group interview the teachers stated they had tracked the number of times the videos had been accessed via the statistics available in YouTube. In total, approximately 40 to 50 views had been recorded, however it is impossible to whether the views were from teachers or students, and whether the videos had been viewed from beginning to end. No other strategies were put in place to improve student engagement during the project.

**Group 4 teachers’ perceptions of the action research process**

In their final interview, the three teachers spoke about the challenges of engaging with the action research process within their specific context. Although they found the professional development aspect of the Euclid Project to be of some value, they had difficulty with the ‘action’ aspect of action research, which is understandable given the vast differences between a traditional, face to face classroom and a distance education classroom where the practice of teaching has many barriers. The limited opportunities to develop positive pedagogical relationships with often reluctant students prevented any improvement in student engagement. A potential solution to assisting these vulnerable students may require a review of current overall practices at distance education centres including a review of how well contemporary technology is used to address issues of engagement.
Initially there were two teachers participating in the action research at Queanbeyan High School. One was the Head Teacher of Mathematics and the other an early career teacher, who left the school for another position during Term 2. Many students at Queanbeyan High School enter secondary education with low levels of numeracy and literacy and the teachers at the school have traditionally found it difficult to engage the students in mathematics. Following the initial two days of professional development and collegial conversations within the Euclid Project, the two teachers at QHS conducted visits to some of the feeder primary schools (also involved in the Euclid Project) to investigate the teaching strategies experienced by their future students. It was noted that mathematics classes were structured differently to the traditional secondary classrooms with students working in small groups, allowing the teachers to work closely with students who required additional support. These observations led to the development of the following research questions and sub-questions:

How does the implementation of small group learning and directed problem solving activities impact students’ numeracy skills?

- In what way can you cater to the diverse needs of a range of students through small group learning?
- How does the implementation of a group reflective journal enhance students’ understanding of mathematical literacy?
- In what way will the implementation of practical, hands on tasks increase knowledge acquisition, development and retention of secondary students?

Group 5: Processes and Outcomes

At the start of the Euclid Project the goals of the two teachers initially involved were articulated as follows: “Gather evidence of students’ growth by: pre and post surveys; student reflections in journal; teacher observations and comments; subjective observation
of student engagement, participation and attitude.” Due to a range of challenging circumstances, only some of these actions took place.

In order to measure growth and assist in focussing their research, the teachers at QHS conducted a survey to identify students’ attitudes and beliefs in relation to their problem solving abilities. The initial survey results and their analysis are included in the final report (Appendix XX). As a result of the survey the teacher implemented a series of tasks for the students to attempt using small group rotations that replicate the types of practices observed in primary classrooms. The tasks were different from what was typically offered to the students. Some incorporated hands-on materials rather than their usual pen and paper activities, and all were focusing on worded problems. In addition, the students were asked to complete reflections on the activities. Later in the year after consultation with some of the other project teams, the teacher at Queanbeyan began the implementation of Problem Solving Mats in order to encourage students to articulate their thinking and solve problems in a systematic way using a step by step approach. These mats were an adaptation of those instigated in Project Group 1, an example of cross group collaboration.

Prior to implementing the new group work strategies, the personal circumstances of one of the teachers led to a long absence and this, compounded with the effect of having one teacher leave the school, led to long delays in the implementation of the action research activities. Another effect of these circumstances was that the actual research activities appeared to be limited to three lessons. Despite the challenges, the remaining teacher continued her efforts to improve the students’ problem solving abilities: “We were also wanting to look at just the extent of hands on activities and how primary school teachers actually relate back to the mathematical work that is involved in problem solving and how they set out the problems”.
During Term 2 the two teachers began planning group activities based on measurement concepts. At that point in time the teachers had expected to have additional classroom support from support staff. The original intention was to implement group work lessons in both Year 7 and Year 8, due to the broad range of academic abilities: “We have students currently in a Year 7 class who are basically operating I would say at a Year 2 level and then a student who is probably operating at Advanced Stage 4, Year 8”. The teachers discussed the implementation of journal writing with sentence starters or prompts to assist students improve their literacy as well as numeracy skills and there was some reported collaboration with the English teacher in this area.

When data was collected in Term 3, three lessons had been implemented with the Year 8 students by the remaining teacher. The original plan to work with Year 7 and Year 8 had changed and the lessons were implemented with Year 8 students only. During the interview, the teacher stated that the students had reacted positively to the group work and hands-on approach, although the range of abilities meant that some students found the tasks less challenging than others.

During the final interview, the teacher reported that no further activities had taken place since the three lessons and the initial introduction of the problem solving mat. A further survey was administered to determine whether any changes in attitude had occurred as a result of those lessons and there did appear to be some improvement in the number of students who understood the problem solving process, which had been a feature of the three lessons. However, there was no significant movement in relation to students’ attitudes towards mathematics. Although the students appeared to have enjoyed the hands-on approach, the group work was not collaborative. Rather, groups of students worked independently on the set tasks, and this may have contributed to the survey results.

“...some of them really got engaged, and others were struggling...”
Group 5: Students’ perceptions of mathematics

Data was collected from a Year 8 student focus group at Queanbeyan HS during Term 2. There was no follow-up focus group interview at the end of the Euclid Project as the students were away on school camp during the final data collection day. The students selected for participation in the focus group (chosen from the students who had returned signed consent forms) were reasonably confident but were aware that it would become challenging in the future. Comments such as: “it’s like good and bad...it’s definitely fun, you learn new things all the time” and “It’s fun but it’s challenging as well when you have to learn something new” represented the sentiments of the group.

During the discussion it was revealed that the participants were in different class groups and not necessarily those students who were the focus of the action research. Because the group did not appear to be a representative sample of the children at the school, they were asked to talk about what other people in Year 7 think about maths. This revealed some interesting perceptions about the more general negative attitudes felt by many of the students with comments such as these: “It’s stupid”, “It’s a waste of time” and “People don’t really want to learn about it”. The participants talked about how many other students didn’t understand how important mathematics is, and as a consequence, don’t achieve well. The students also discussed how ability grouping influenced the perceptions of those who were placed in the lower classes “they feel like they’re in the dumb class”.

Group 5: Teacher’s perceptions of the action research process and projects?

When discussing the experience of being involved in the Euclid Project and having the opportunity to conduct action research, the remaining participating teacher at Queanbeyan High School discussed some of the challenges that were experienced. These included the challenge of working alone with minimal support. It was felt that the interaction with the
neighbouring primary teachers that occurred at the beginning of the project was useful. However, it would have been better if there were more participating teachers at Queanbeyan HS to allow for collaborative research. The participants were provided with the opportunity to collaborate with other schools at the start of the Euclid Project but this option was not taken up by the teachers at Queanbeyan High School. This may have been the case due to having two teachers begin the process. However, when one teacher left this made the research more challenging for the remaining teacher. Although encouraged and supported by the research team, the timing and circumstances for the teacher at this school limited the action research that occurred.

**Group 5: Next Steps**

During the final interview the teacher at Queanbeyan High School indicated that she would like to collaborate more with neighbouring primary schools to share strategies and improve students’ transition from primary to secondary school.
SUMMARY AND DISCUSSION

As detailed in the introduction of this report, the Euclid Project was initiated due to an awareness of falling standards at national, state and local levels. The Project was initiated by the Network Director to improve student outcomes and engagement through teacher professional learning in the form of action research, with a focus on middle years mathematics. The Director also saw the Euclid Project as a vehicle to improve cooperation and collaboration between schools, particularly during students’ transition from primary to secondary:

I need to see teacher focused on innovative and explicit teaching of mathematical skills and knowledge. I need teachers to be less concerned about content and more on understanding. Consolidation of skills without boredom and simple repetition...I need school communities to recognise the value of mathematics in their lives.

The purpose of this report was to explore the following questions in relation to the action research conducted in the Euclid Project:

i. Can the implementation of a range of action research projects within and across schools from the same school district promote change in the teaching and learning of middle years mathematics?

- What are the individual action research projects implemented in the Queanbeyan network of schools?

- What were the processes and outcomes of those projects?

ii. Did students’ perceptions of mathematics change as a result of the action research projects?
iii. What were the teachers’ perceptions of the action research process and projects?

The following section seeks to address those questions and briefly explore themes and observations that emerged across each of the action research groups.

**Can the implementation of a range of action research projects within and across schools from the same school district promote change in the teaching and learning of middle years mathematics?**

As would be expected, the amount of change witnessed across the five projects differed significantly across and within project groups. There were variations across the projects in both teaching and learning. For example, teaching practices did not appear to change at Karabar Distance Education Centre. This could be attributed to the nature of distance education, the nature of the group’s research focus and the challenge of embedding new digital resources into a program that was still mostly print based. At Monaro High School, the research activities were implemented as add-on activities rather than embedded in day to day practice due to an apparent lack of support and leadership from within the mathematics faculty (there was no Head Teacher, Mathematics at the time of the research) and due to the pressure of having to keep up with non-participating colleagues in terms of mathematics content due to the faculty’s scope and sequence document. On the other hand, schools such as Jerrabomberra and the secondary teachers at Jindabyne Central School made significant changes to their day to day teaching practices. Less reliance on text books and worksheets at Jerrabomberra and the faculty-wide introduction of the Problem Solving Mat at Jindabyne resulted in significant shifts in practice.

The shifts that did occur in teachers’ practices resulted in changes to the way the students were learning mathematics. For example, at Cooma North Public School, the students adapted to a new routine of problem solving and reflection as a result of their teacher’s action research. Their mathematics learning became more focused on the processes of mathematics (Working Mathematically) (Board of Studies NSW, 2012) than it had prior to
the research. At Jerrabomberra the students’ work consisted of less drill and practice style tasks to more open-ended, investigation based tasks.

Did students’ perceptions of mathematics change as a result of the action research projects?

There was some evidence of changes in students’ perceptions of mathematics in some of the participating schools, however this also varied widely across and within projects. There was significant variance in the duration and adaptation of practices that were trialled as part of the research activities. For example, at Queanbeyan High School the participating teacher only implemented a new strategy in three lessons so it is not surprising that there were no reported differences to student perceptions. Added to this, the students were not able to be interviewed by the researchers on conclusion of the research. At Karabar High School there appeared to be no significant change to student perceptions of mathematics and this may also have been due to limited research activities and the compilation of focus group participants (derived from only one class group). Conversely, at schools such as those involved in the Queanbeyan group (Group 3) and Jerrabomberra Public School, there was evidence that student perceptions had definitely shifted. The students at these schools had begun to consider mathematics as being fun and also began to recognise that their teachers had developed more capacity to cater to their mathematical learning needs, resulting in improved engagement.

What were the teachers’ perceptions of the action research process and projects?

The majority of teachers found the action research process useful in terms of increasing their awareness of their individual practices and the implications of these practices on the student experience (Mertler, 2018). Again, there were a range of reactions to having the opportunity to conduct action research. Although the teachers had access to professional learning and advice regarding the actual processes involved in conducting action research, the quality of the research varied significantly. Some of the teachers involved perceived action research as
an added burden and a ‘project’ rather than a practice to be learned, yet others saw the action research as an opportunity to develop new practice. The following is a quote from a participating teacher at Jerrabomberra whose practices had begun to transform as a result of her participation in the Euclid Project. The teacher was asked if she had advice for others considering embarking on action research:

*I would say to embrace it. It is really important. And to be brave enough to try the changes because often when you try them you will be surprised at the results you get because you know often we go back to that sort of same default thing because we know it and we know it well but when you try something new and you get a different response it can become your new default kind of thing. So, I would say just embrace it and actually try and definitely don’t be afraid to. Because – and also if it goes wrong it is really not the end of the world. Not the end of the world. If the lesson doesn’t work out the way you planned or whatever you can always go back to it and fix it up...*

**Observations of the Teachers’ Action Research Processes**

As noted earlier, during the Euclid Project the teachers were provided with professional learning in relation to the processes involved in all stages of action research. This occurred during the full day sessions where the teachers came together in Canberra and also during the various visits to schools and online meetings with the researchers. As is typical with newcomers to action research the teachers in the Euclid Project spent significant time refining the issue/s they wished to address prior to articulating their research questions with the assistance of the research team. A notable shift that did occur early on in the project was that the teachers’ initial motives for participation evolved from simply gathering more teaching resources and strategies to a stronger focus on practice, and this then reflected in their emerging research questions and sub-questions.

Another noticeable shift that most of the teachers made during the action research process was a move away from perceiving action research as something to be ‘done’ to students to something that results in a change of teaching practice. Also noted was a misconception that
conducting surveys of students and/or colleagues constituted research. Of course, surveys are a valid methodological tool used in research, but in the case of the Euclid Project, several teams conducted surveys, analysed them to some degree, but did not make strong links between the survey outcomes and their research activities. This implies a need to take more heed of student voice (Attard, 2011; Munns & Woodward, 2006) and perhaps to use a more diverse range of evidence when considering all stages of the action research process.

**Shifting Teacher Perceptions of Mathematics**

During the professional development days held in Canberra at the beginning of the Euclid Project, the teachers’ interpretations of the mathematics curriculum were focussed on mathematics content as opposed to mathematical processes. Shifts in these interpretations occurred through the project and this resulted in all of the research questions and activities relating in some way to the processes that are articulated in the Working Mathematically strand of the current NSW mathematics syllabus (Board of Studies NSW, 2012). Rather than teaching mathematical content in isolation and without context, the teachers began to address the content through a problem solving approach (Clarke, 2003; Lubienski, 2000; Schoenfeld, 2014). This was most evident in Group 1 with the introduction of the Problem Solving Mat. Further evidence is in the use of student journals to record reflections of learning. Where it worked well, the teachers gained an increased awareness of their role as a teacher and gained a better understanding of the curriculum and their students’ abilities. These are all important factors that contribute to positive student engagement with mathematics (Attard, 2014).

Shifts in perceptions relating to the primary/secondary mathematics classrooms were also evident during the Euclid Project. For example, at the very first professional development day there was a definite divide between the primary and secondary teachers. There was much discussion about mathematics teaching that implied an ‘us and them’ attitude. The opportunities provided by the Euclid Project resulted in teachers visiting each other’s schools, classroom observations, and research teams that worked across primary and secondary schools. This resulted in significant shifts in perceptions of what goes on in
primary/secondary and an appreciation of the practices and challenges experience within different school contexts in relation to mathematics education. It also resulted in the beginnings of a community of practice that shared understanding of engaging mathematics pedagogy and common language in regard to mathematics teaching and language (Wenger, 2000, 2011).

**From Student Engagement to Teacher Engagement**

An unintended outcome of the Euclid Project was a positive change in the participants’ engagement with the teaching of mathematics. Of course, this varied from teacher to teacher. There appeared to be a direct relationship between the depth of engagement with the process of action research and the sense of improved engagement with teaching (Attard, 2015). Those who could recognise notable differences to their own practices and noticeable differences within their students’ engagement reflected on the improvement in their own engagement with teaching. These teachers felt a sense of renewal and reinvigoration due to their changed practices and the visible differences they made to student work and affect.

The various levels of collaboration within and amongst schools also contributed to improved teacher engagement. Those participants who actively engaged in collegial discussions reported feelings of greater confidence and satisfaction with the research activities and outcomes than those who were less collaborative. For example, the group of teachers from Queanbeyan East, South, and West Public Schools found their collaboration to be particularly valuable and transformed the previous competitive relationship. The following two quotes are drawn from the final group interview with the Queanbeyan primary teachers and provide insight into the success of this group’s collaboration:

*I think it has brought us together to discuss the ways that we are teaching and share ideas as to the way we can support each other … finding out what our kids are doing in mathematics and I think that has been a really good.*

*That has actually helped the bond between ourselves too I think doing this because as I said we used to talk about schools and now we talk with schools.*
The Role of Leadership

Leadership, in its various forms, played a critical role in the success of the various groups during the Euclid Project. The leadership of the network Director was critical in terms of the project’s conceptualisation, and the organising and providing of financial support for teachers to attend the group meetings and to take time out from their teaching to work with the researchers. The Director also encouraged support from each of the participating schools’ Principals to ensure teachers were supported for the duration of the Euclid Project. As would be expected, the levels of support varied due to a range of reasons including staff leave etc. It was clear from a researcher’s perspective that teachers who had principals that played a more active role in their research were able to engage in their research in more depth.

The misconception of action research being a finite rather than a cyclic process also contributed to variations in the levels of support from leadership (Bonner, 2006; Mertler, 2018; Mills, 2003). The cyclical nature of action research needed to be more evident within some of the research groups and perhaps through better support of leadership in some of the participating schools this would have occurred. It is also critical that those in leadership have a clear understanding of action research and value the importance of disseminating results. Recognition of the accomplishments of the research, sharing the outcomes with colleagues across the schools and building upon what was achieved is reliant on all levels of school leadership. At the conclusion of the Euclid Project there was evidence that this was to occur in some schools, particularly those whose principals were in attendance at the showcase day.

Observations from the Outside

The inclusion of an outside expert is a typical feature of action research. In this project, the research team had a dual role – that of critical experts and as researchers of the overall Euclid Project initiative. Having external critical observers was beneficial in this case as it provided
participating teachers with a different perspective and expert subject related advice that they may not normally have had access to. In addition, they had expert advice and feedback in relation to the conduct of action research. The ability of the research team to visit the teacher research teams at schools was also useful. This assisted the researchers in understanding their contexts and allowed them to provide more relevant advice and feedback.

Although there were differences in the results across the teachers’ action research and varying degrees of success, the overall initiative did result in positive benefits for most of the participants. The initial objective to create greater collaboration across primary and secondary schools across the network was successful and this was acknowledged by those teachers working within those particular research groups that combined primary and secondary teachers. In some cases student engagement with mathematics was definitely improved as was teacher engagement. Teaching practice showed signs of change from traditional, text book based approaches to approaches that were more student-centred and problem solving based.

The research evaluations that were presented at the Euclid Project showcase day and in the teams’ project reports were a beginning for these teachers as action researchers. Further opportunities to develop analytical skills will be of benefit to these teachers, as would further professional learning in relation to action research as a practice rather than a finite project. Some teachers will no doubt move on from the Euclid Project and consider it as just that – a project. Others will continue to practice as action researchers and will continue the collaborations that began as a result of the opportunities provided by their involvement in the Euclid Project. The following section of this report includes a set of recommendations that have emerged as a result of this research.
RECOMMENDATIONS

• Future professional learning opportunities in mathematics within the Queanbeyan network and beyond should focus on strengthening teachers’ understanding and implementation of the Working Mathematically strand to ensure it forms the core of their mathematics teaching.

• To assist in developing deeper conceptual understandings and problem solving skills, school leadership should support teachers to focus on developing student conceptual understanding as opposed to timing teaching and learning according to the demands of scope and sequence documents.

• Teachers who were successful in their action research within the Euclid Project are encouraged to become mentors to other teachers within or across schools in order to promote a culture change in relation to mathematics education practices.

• Student voice in relation to mathematics teaching and learning should have more prominence in relation to programming, planning, and pedagogy in mathematics.

• Continuation of the relationships between the primary and secondary mathematics teachers who participated in the Euclid Project is strongly encouraged and should be supported by school leadership.

• Further opportunities for collaboration across the middle years of mathematics is strongly encouraged to ensure alignment in pedagogical practices.

• Support for participating teachers to continue developing the practice of action research is strongly recommended to ensure action research is an ongoing aspect of practice rather than perceived as a finite project.

• The use of an external critical friend in future initiatives is recommended to ensure accountability and to provide additional expert advice and support.

• Future iterations of cohort based action research should include an expression of interest process to ensure participants and school leaders are committed to the process.
REFERENCES


Board of Studies NSW. (2012). Mathematics K-10 Syllabus. Board of Studies NSW.


