TEACHERS AS RESEARCHERS (TAR21) - FINAL REPORT

Faith Lutheran College Redlands (FLCR)

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Project question: How does developing reflective practice affect teacher pedagogy and influence student higher-order problem solving in mathematics?

INTRODUCTION

While it is agreed that higher-order thinking skills must be included in teacher unit plans, more could be done to actively differentiate instruction during lesson planning in order to capture the interest of high achieving (HA) students. The researchers in this project aimed to investigate whether by using reflective practice and group collaboration; they could improve their pedagogy and subsequently influence their students' learning.

A key component of the Marzano pedagogical framework, currently implemented across the college, is the necessity for teachers to reflect on their teaching and their students' learning in order to improve student outcomes. The effectiveness of solving problems in mathematics was selected as a teaching-learning focus area because of concerns that HA students were not succeeding in this area. The students either lacked persistence with problem solving tasks or avoided them altogether. The intention of the researchers was to investigate the possibility of changing their approach to teaching problem solving in mathematics through reflective practice in order to engage these students. They aimed to explicitly teach the students a variety of problem solving strategies encouraging the development of higher-order thinking skills (HOTS) and mathematical thought processes. By using reflective practice to drive the changes to the teaching-learning cycle, these researchers were encouraged by the extent of the improvement both in their pedagogy and in the students' attitudes towards problem solving in mathematics.

LITERATURE REVIEW

Before commencing this project, it was important for the researchers to have clear and common understandings about Action Research, Reflective Practice, Problem Solving processes and Higher Order Thinking Skills (HOTS). Action research is about reflective practise; becoming a reflective teacher involves identifying those areas one needs to change in order to improve one's teaching. What is reflective practice? It is asking: "What is it that I typically do?" and "What can I do differently to improve?" Taking time to reflect and record what one sees during classroom practice is a discipline that requires time and effort to develop.

Rooney (2012) used a journal to record her reflections during the research process. She recorded what she did and what she learnt after each lesson. This is a research approach that enables teachers to better understand themselves and their own processes of learning and growth in order to improve their practice. This provided the FLCR research team with a suitable model for this action research project. Rooney wanted to improve her teaching of mathematics by using inquiry based learning which used open-ended, student-centred, hands-on activities based on real-life problems. This article discussed many of the issues that we had been dealing with, for example, using time effectively and how to develop classroom activities that are based on real life situations. She approached her research in two cycles focusing firstly, on guiding the students through an inquiry approach developing greater persistence, then in the second cycle the students would present their findings realising the importance of the way the solution is set out and presented.

A gap exists that lies between where one stands facing the problem and how one gets started on the path to a solution (Pennant, 2007). Sufficient time for students to think and "play" with the problem was important; time to test out ideas, take risks, discuss ideas, etc. The teachers had to factor in sufficient time for the students to engage with the tasks and to follow through with the problem solving processes. In the first year of their study Miri, David and Uri (2007) found that persistence in teaching higher order thinking skills improved students' attitudes towards mathematics and more specifically "problem solving". This was also found to be true in this project at FLCR.

Because students need to undertake regular testing in the school context, the concept of "teaching to the test" regularly surfaced. This was something mentioned by Miri, David, and Uri (2007). Standardised and NAPLAN testing was found to take considerable time at the start of the year; interrupting the flow of the problem solving program in this project.

Scott, Clarkson, and McDonough (2011) investigated the effective characteristics of professional learning communities (PLCs) that were evident during team discussions by the teachers in their study. This team of teachers participated in a Contemporary Teaching and Learning Mathematics (CTLM) program. Many of the characteristics of PLCs, such as reflective dialogue and shared practice, were experienced during team collaborations with the researchers. The teachers had to collect evidence of their classroom practice and their students' responses in a portfolio to share together with a reflective commentary when they met in collaborative teams. They used a digital SAPP (Self Analysis Professional Portfolio). This appeared to be something that the FLCR researchers could investigate in the future as a means of collecting and presenting data for shared analysis.

METHODOLOGY

This project was undertaken in an Independent Lutheran school (Prep to Year 12) located on Brisbane's bayside. The research focused on high achieving (HA) mathematics' students in Years 4, 5 and 6 in the Junior School. The researchers included three teachers from the respective Year 4, 5 and 6 classes and a Learning Enrichment teacher.

Action research methods underpinned the design and were applied within and across units to systematically evaluate, review and respond to the data (Fletcher, 2000; Skirret, 2002). Individual teachers' trialled new practices as per student needs and observed the effects of these in their classrooms by way of collecting data. They then reflected on and analysed the data in order to make informed decisions and plan the next phase of their research.

As research teachers we were able to meet regularly to seek answers to everyday problems within our classrooms and try to find new ways to improve instructional practice and student learning. Through reflective dialogue and taking an inquiry stance we were

able to discuss strategies and cultivate professional relationships as a Professional Learning Team (PLT).

The timeline for the three action research cycles were as follows: The first cycle ended in November 2014, the second cycle at the end of June 2015, the third cycle at the end of November 2015 and the forth cycle will continue into 2016. See Figure 1 for a diagram representing the three cycles of Action Research undertaken in this project.

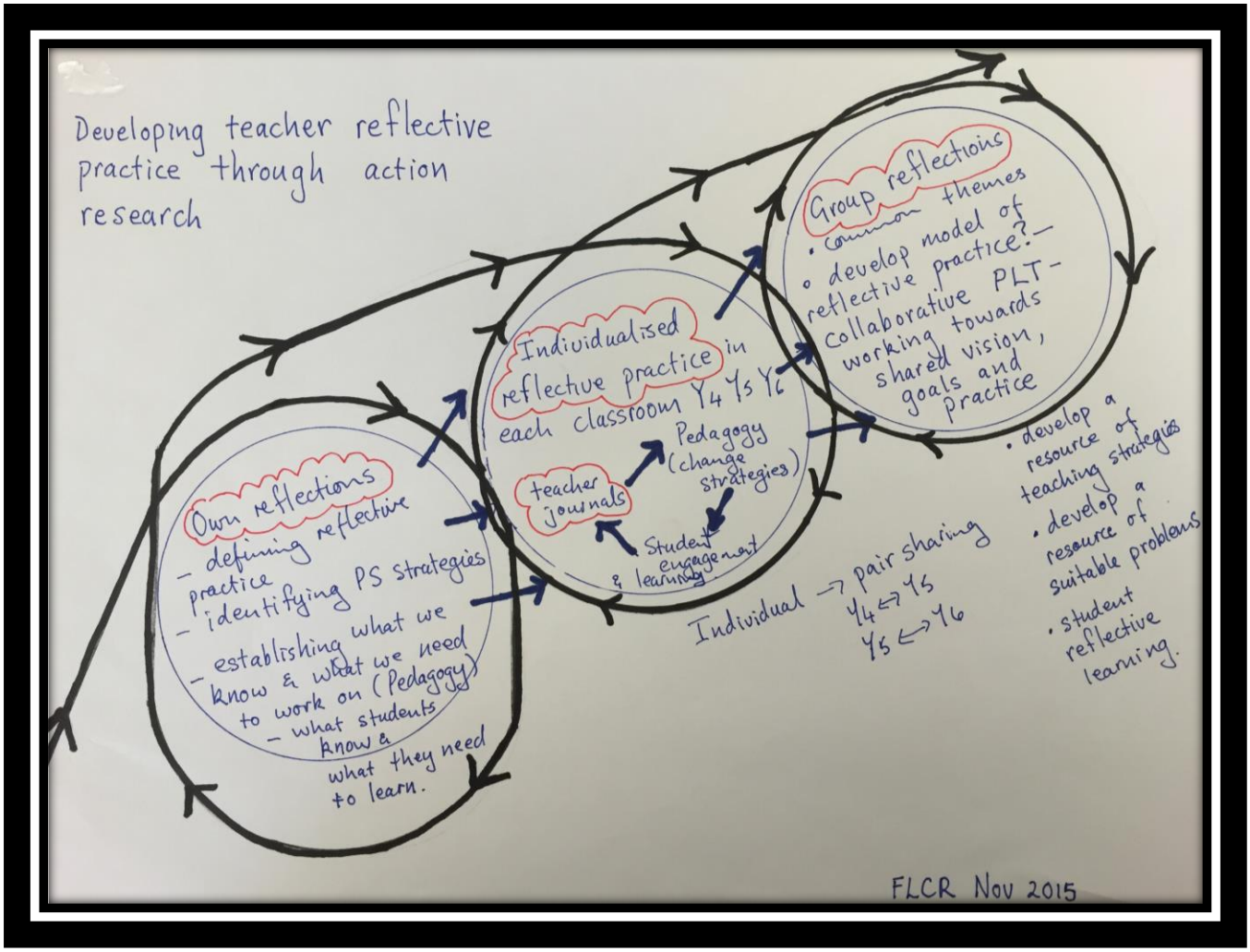


Figure 1: Developing teacher reflective practice through action research cycles

In 2015 flexible learning groups in Mathematics were implemented in Year 5 and 6 so that two of the research teachers were working with whole class groups of HA students. The year 4 research teacher was not able to work with this arrangement but implemented ability groups within her class. The challenge was to be able to spend dedicated time with the high achievers in this class as other students were very demanding of her time.

a) CYCLE ONE

In the first action research cycle the researchers began to record their own reflections concerning their instructional practice and the students' response. They also began to develop their knowledge through personal professional learning, pre-gathering information concerning: (HOTS, Reflective Practice, Problem solving strategies, open ended questions, qualitative data collection).

During this phase it was "a challenge to systematically view ones' teaching practice critically." The process of written reflections was a new experience for the researchers. However, with the continued study and reading of Marzano's pedagogical framework understandings of using reflections to critically review pedagogy and trial new approaches became less complicated and more manageable. In Cycle One it was difficult to hold onto the primary focus of our research question involving the effect of reflective practice on our pedagogy. The focus tended to be on problem solving and how to engage and extend the students through higher order problem solving processes in Mathematics. However, it was necessary at this stage to define and establish common understanding of teacher pedagogy. The teachers had to implement and trial ways of teaching problem solving and engaging students providing a focus for the reflections.

A survey was administered to selected 2014 years 4, 5 and 6 students in order to gauge student attitudes towards Mathematics and their knowledge of problem solving strategies providing a base line from which to measure gains.

b) CYCLE TWO

In cycle two individualised reflective practice occurred by the researchers in each class (Year 4, 5 & 6). Some pair sharing occurred between Y4 & 5 and Y5 & 6 researchers. During team meetings the researchers shared what they had done in their respective classes and what they had learned.

During phase two our reflective practice processes were refined and these were used to inform our teaching pedagogy. Changes were implemented to the way the reflections in our journals were recorded. A special purpose mathematics journal was

established in which reflections were recorded. After discussions the following structure to our reflective journals was implemented:

- Learning Goals
- Lesson plan
- Copy of activities and student work samples
- Reflections on how lesson went
- What to do next lesson – where to next?

Journaling assisted us to see what worked well in our classes – the type of content that students enjoyed and when they were most engaged. We also found that as a result of this recording of reflections in mathematics that there was a follow on effect in the other subject areas we teach.

During this phase we started observing a change in students' attitudes towards problem solving. Students no longer "moaned" when they knew they were working on problem solving and they were more interested in working on open-ended mathematics problems and real life tasks. Year 6 students were prepare to undertake activity worksheets at home to prepare for tests and spend class time working on more interesting inquiry based learning tasks. Students were also sharing their mathematical thinking more freely with each other and to reflect on their own learning.

During this phase the research teachers had the opportunity to share their research with Junior School Staff during two staff meetings. Teachers were interested in the positive results they were achieving in Mathematics.

c) CYCLE THREE

During cycle three the researchers began group reflections in order to establish common themes through their analysis. They agreed on a similar structure for collating reflective data that included: planning, goal setting and teaching as well as student responses. Self-evaluation and recommendations for future teaching practice was included. Difficulties were encountered during this phase that limited the opportunities for the teams to meet

together with sufficient frequency slowing down the collaborative process. Teachers continued with the reflections in their own classes.

d) CYCLE FOUR

The researchers aimed to implement a model for collecting and sharing reflections e.g. SAPP (Self Analysis Professional Portfolio) but had insufficient time to do this in 2015.

DATA COLLECTION

Participants	Data instruments	Whom (and where if relevant)	When	Why	How
Year 4, 5 and 6 students who were identified as high achieving students in Mathematics	Survey	Year 4, 5 and 6 students of research teachers.	2014	To ascertain students' attitudes toward learning mathematics and problem solving; to establish students' knowledge of a variety of PS strategies.	Survey Monkey - 25 questions with scaled responses. The results were collated and analysed in the first report.
Research teachers in Years 4,5 & 6	Reflective Journals	Mathematics lessons – teaching and planning, analysis of students' responses.	2014 and 2015	Focus of research – Reflective practices will lead to improved teaching pedagogy and student learning outcomes.	Written personal responses to effectiveness/success of a lesson. Analysis of key recurring themes.
Research teachers & students	Student Observations: Video clips & photos	Year 4, 5 and 6 students who were identified as high achieving students in Mathematics	2014 and 2015	To ascertain if there was improved proficiency in students' ability to talk mathematically and an improved positivity towards mathematic problem solving.	Observations of students working and presenting their work. Video clips & photos; student posters and work samples.
	Work samples	Identified samples	2014 and 2015	Written evidence of student improvement in processes and explanation of their mathematical thinking.	Exemplars Photos of student journals
	Videos and pictures			Video/visual evidence of student improvement in processes and explanation of their mathematical thinking.	

	Interviews	Selected students	2014 and 2015	Evidence of changes to student attitudes towards problem solving and open ended mathematic activities.	Verbatim recording. Video interviews.

ONGOING CHALLENGES

The researchers continued to struggle with the challenge of time. One teacher imagined that if she had focused 'project time' then her reflections would be deeper and more meaningful to everyday teaching. "It would be great to get just one session a week to use for reflections, readings and preparation".

The students had their own struggles to overcome, such as:

a) It was discovered that students' poor number skill mastery and low reading comprehension ability created cognitive overload when these students were faced with problem solving questions.
b) Initially we didn't realise that students would be so reluctant to use a variety of materials and strategies. They expected to come up with an answer immediately which is what they perceived that "smart" students did.
c) The students liked to work within their comfort zone and didn't want to appear as if they didn't know what they are doing. They were afraid to take risks in their learning for fear of getting something wrong.

This was a mindset that we were looking to change. How could we help students to be less fearful and more reflective? Could this Mathematics' approach be used to solve other real life problems too?

DISCUSSION

A diagram depicting the connection between teacher reflective practices, changes in teacher pedagogy and student learning as each informs and influences the other can be seen in Figure 2. Positioned in the centre of the diagram are the characteristics that are evident when teachers openly share their reflective practice in collaborative professional

learning teams. As a result both teachers and students experience positive affect; improved capacity and increased achievement.

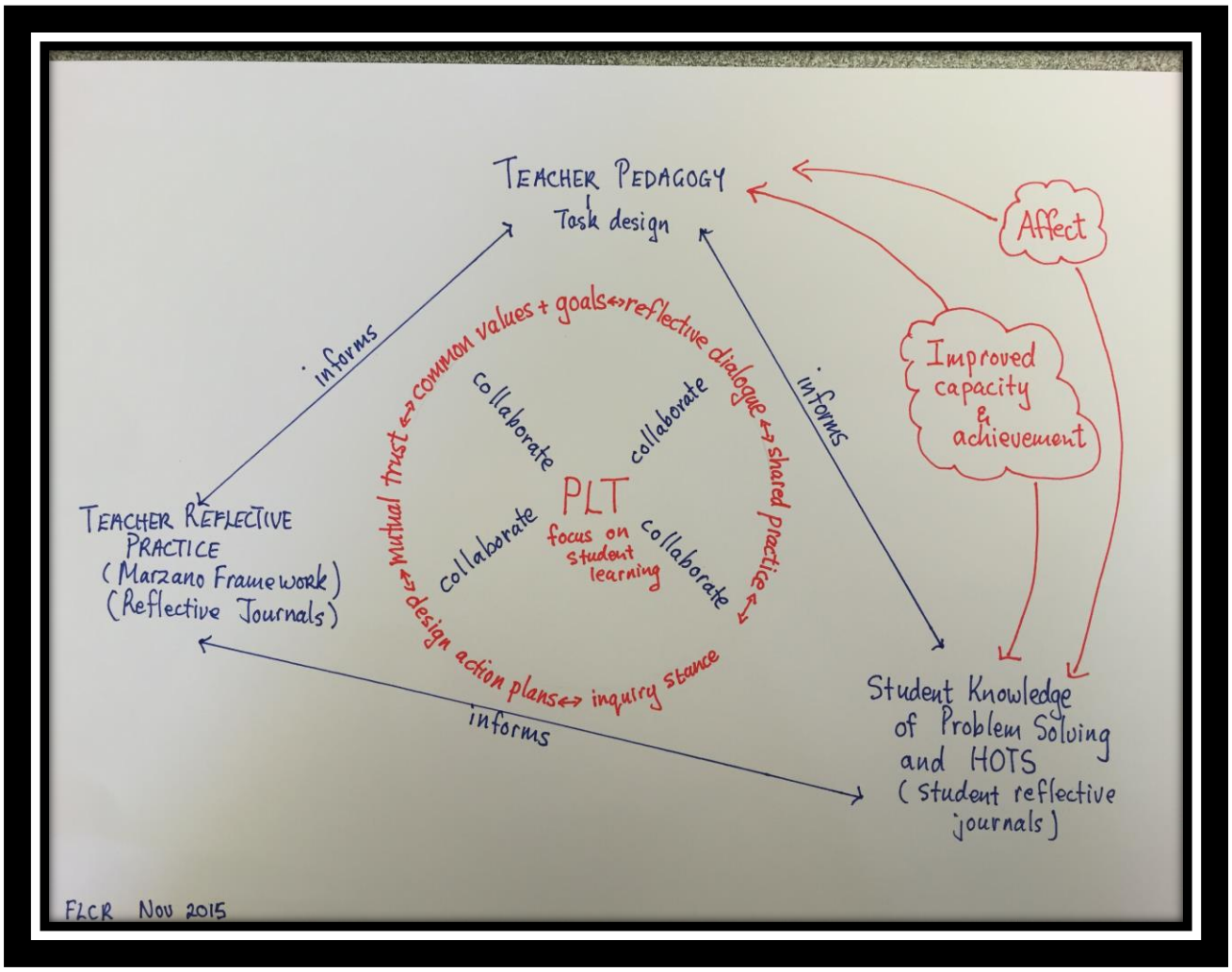


Figure 2: A representation of the influence of reflective practice with collaboration on teacher pedagogy and student learning.

Certain themes, that affected change in teacher practice and student learning as a result of teacher reflections, became apparent when these teacher reflections were shared. These themes have been organised under the following headings:

1. Social
2. Affect
3. Cognition
4. Physical

1. **Social**

a) Teachers

- Improved attitude to sharing openly about teacher practice. As a Research Team we began to openly share our challenges and successes, seeking help and support from each other. We have shared resources and used common websites in our quest to find new and exciting resources. We have sought out each other to gain advice in particular situations and have implemented other teachers' ideas.

Example: The teachers made an effort to contribute to team discussions by taking videos and photos of students working and collected student work samples to share with colleagues at the TAR team meetings.

- Building a relationship of mutual trust and respect with the teachers on our team.

Teachers were able to invite one another to observe them teaching and welcomed critique.

- Shared responsibility for student learning between classes.

In year 6, although we have our "own class' students", we can share the responsibility of teaching and caring for "all students". If necessary we met with parents together, or we shared data with each other about a student and reported back to parents. Example: I had a student who was being observed by a psychologist who met with me for an assessment. My colleague, who taught this student mathematics, was able to provide a second set of observations for the psychologist.

Because of this project, the Year 6 classes were "ability" grouped enabling the Year 6 researcher to work with the HA students and help them to gain deeper understandings of concepts. This also allowed the Year 6 teachers to make the "intervention support" group smaller. More teacher aide time was allocated so that the high need students also received more targeted instruction.

This has also led to a willingness to experiment with other formats with our Year 6 classes in different subject areas, such as, all girls or all boys groups.

Example: In Science segregated and co-ed classes were offered. Year 6 teachers have evidence of an overall improvement of results for girls. The three Year 6 teachers taught

each group in turn. This has been beneficial for our teaching skills because we have been able to reflect and then teach in a way that best suits, boys, girls or a mixed class.

- Common values, goals and vision around improving teacher pedagogy and student learning.

This extended to creating relationships of trust sharing problems and supporting other teachers in their learning. For example, having a common work ethic and sharing our work journals and reflections helped us to re-evaluate our note taking and refine the process.

b) Students

- Greater task engagement

As a result of this project, the students are able to stay on task during problem solving activities. This had improved from earlier in the year. They enjoyed experimenting with different ways of solving the problems.

Example: A Year 5 student was quoted saying “time seems to go so fast when we are doing problem solving” another student was quoted as saying “problem solving is interesting and fun”. Yet another student said, “I stay focussed during problem solving because it is challenging.”

Example: At the end of the lesson, John’s first comment was, “That was the “funnest” Maths lesson ever! Can we do more like that?”

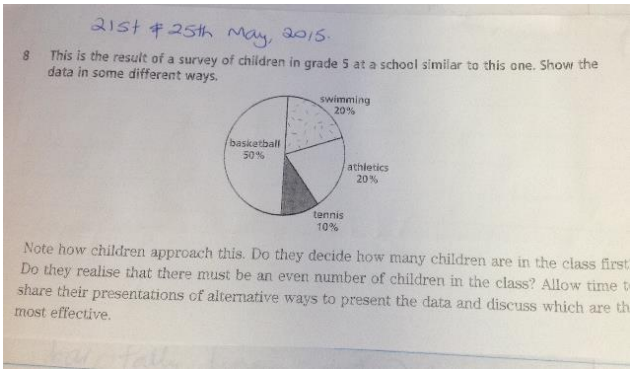
Example: During a “Funfest” information Data Unit (Year 6), that involved an application of real life skills, such as, writing surveys, collecting data and presenting findings, the students could see a purpose to the work they were doing. The class received a visit from a Public Relations Co-ordinator who explained how this data type of data collection assisted her with her work.

- Working together with learning partners

As the year progressed, the students had greater variety in their groupings. Initially they just wanted to work with their friends. These two students are not in the same friendship group or home class and would probably not have worked together at the start of the year as they did by mid Term 3.

- Sharing openly

Students more willing to share their findings. Would like to prepare posters and present these to the class. Discussion of findings became more open – students would ask each other questions based on their own findings and how others went about finding solutions or why they worked in a particular way. Questions were asked in a non-threatening way.


21st & 25th May, 2015.

8 This is the result of a survey of children in grade 5 at a school similar to this one. Show the data in some different ways.

Note how children approach this. Do they decide how many children are in the class first? Do they realise that there must be an even number of children in the class? Allow time t share their presentations of alternative ways to present the data and discuss which are th most effective.

Example: Open ended data/graphing question.

Student question: What were the original numbers they used for their data?

Whenever the students complete a task, they are more willing to share their working with the class. They are also eager to share their understandings with other students.

(Insert 'Girls Group Sharing' video)

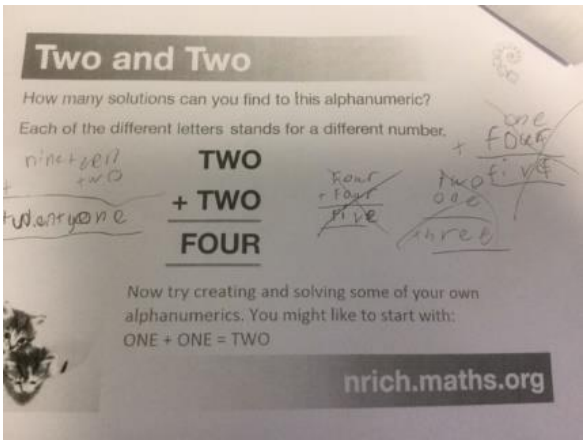
By making problem solving a part of every lesson, the students were more comfortable sharing their knowledge and processes with the group. They often shared in small groups but are also happy to speak in front of the whole class. A change in classroom culture has led to more questioning by the students – more risk-taking and more peer support in problem a solving environment. There has been a shift in student attitude toward problem solving. Students no longer 'moan' when they know we will be doing problem solving activities.

- Learning Partners and working in small groups:

As a result of working with the Marzano Instructional Framework, teachers have learnt that students work best when in groups of three. By working in groups of three, I have discovered that students all take part in the learning. When the students worked in pairs, one person often did the bulk of the work. When the students work in a group of four, they tend to leave someone out and there is a greater risk of off-task behaviour.

The students generally worked in groups on problem solving activities suited to their learning styles or ability levels.

One teacher noted that the classroom was a 'hive of activity' during problem solving activities. Students were noisy, and engaged. They enjoyed sharing their ideas and working together in order to find the best solutions to the problems.



For example, students were working on a problem 'Two and Two' from the "nrich.maths.org" website. The problem involved the students finding several solutions to an alphanumeric problem. They were working in pairs or groups of three.

2. Affect

a) Teachers

- Gained confidence in their ability to teach HA students

Teachers were more willing to try new strategies and present their students with greater challenges. One teacher has been able to introduce more complex problems for the more capable students who have shown increased confidence in higher order problem solving.

- Teachers have developed persistence and resilience as they have worked hard to overcome difficulties while undertaking this project. They have learnt to support and encourage each other recognizing that each has their own areas of strength and weaknesses.
- Enjoyment of teaching increased

Noticing individual students make progress in their HOTS has given teachers a sense of accomplishment. It has been satisfying for teachers to be able to connect with their students individually. As a result of a higher level of student engagement in tasks, teachers are able to spend more time working with individuals or groups of students.

One of the teachers stated, "I feel that I have become more a facilitator in student learning and have found this rewarding. While students are working on investigations, it means that I can spend some one-to-one time with students that maybe isn't always available when students just work on worksheets. The students are better engaged and more resilient enabling them to tackle problems independently before seeking help."

- Developing a more positive attitude towards sharing and collaboration

The teachers have become more tolerant of each other's differences and more willing to work together as a team. Together they have become more inclined to contribute and less competitive.

b) Students

- Improved attitude towards problem solving in mathematics

A greater willingness to undertake problem solving tasks instead of worksheets occurred. This was a change from the students' prior avoidance of such tasks.

Example: On 29th April, 2015 the Year 6 teacher discussed with the students the need to do paper and pencil tests and the necessity to practise these. The students agreed (enthusiastically) to the teacher's proposal that they do the worksheets for homework so that in class we can do investigations.

According to the survey that the students completed at the beginning of this project, the attitude of students toward problem solving (and Maths in general) was poor. They didn't know strategies for problem solving and they thought that it was all too hard. Subsequently, the students worked harder during Maths lessons so that they could work on a problem solving task at the end of the session. As stated above, when asking the students now about problem solving in mathematics, they responded with the following

statements: “time seems to go so fast when we are doing problem solving” another student was quoted saying “problem Solving is interesting and fun”. Yet another student said, “I stay focussed during problem solving because it is challenging.”

Students were reluctant at the start of the year to undertake problem solving and lacked persistence to complete tasks. This has improved with a greater determination to arrive at solutions. Now, students happily engage in problem solving and ‘complain’ when a change of routine means they are ‘missing out’!

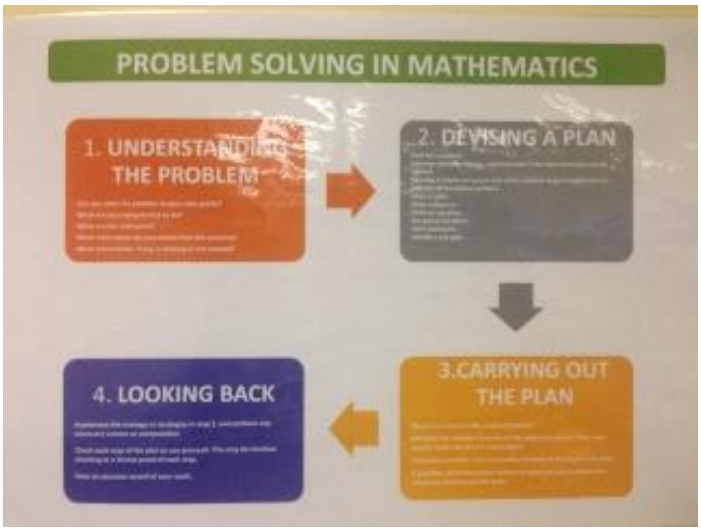
- Risk taking improved

The students demonstrated an increased willingness to take risks by completing more problem solving activities at an increased rate. Students were also more willing to take a risk, especially when they knew that there is not one specific answer to the problem. When the students were completing the ‘Dice Train’ problem, they used the strategy of ‘Trial and Error’ throughout the problem to come to the various solutions.

- Greater persistence and engagement to solve a problem puzzle.

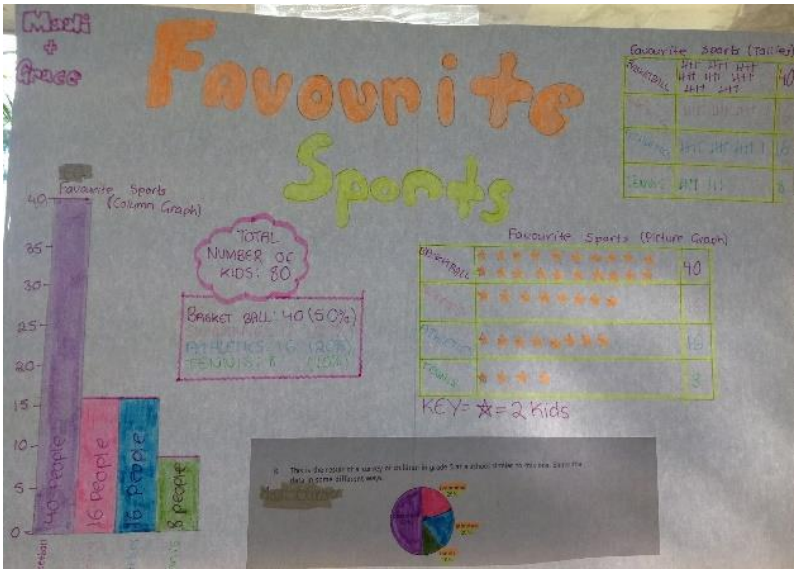
- Performance-anxiety decreased

The teachers found that the students in general were less anxious in Maths classes. The reason for this might have been because the approach between Years 4, 5 and 6 has been streamlined. In Year 4, the students learned the strategies and process for Problem Solving in Mathematics. Then when they moved to Year 5, they were prompted about the strategies while they still work with the process of Problem Solving. By the time they reached Year 6, the students are confident with the strategies and the processes and it has become automatic. Here is an example of how the students were taught to approach a new problem:



The students became more willing to share their findings with their peers and less concerned about being wrong. All students are willing to share their findings and make presentations in front of their peers.

Example: Below is a sample of the type of presentations students would make. There was a preference for "old school" posters over electronic presentations.



- Students developed relationships of trust

The students have developed a sense of trust toward their peers and readily participate in group work or problem solving tasks with a buddy. They have learnt to contribute as well as

to consider all possibilities. There is more than one correct method and in many cases more than one possible answer to the problem! Students were more willing to present their findings and question one another.

- Greater willingness to try new challenges

Independent work remained challenging for the less abled groups in some of the classes but the more capable students enjoyed the challenge of a new problem.

Example: One student commented about how much she enjoyed a problem from the "nrich.maths.org" website called "Escape from the Castle". This was a multi-step problem that required solving one problem before being allowed to move to the next.

3. Cognition

a) Teachers

- Teacher Reflections

Through regular journal reflections, teachers have been able to enhance student learning. According to one of the teachers, her reflections have improved, because she made the reflections more specific and detailed than previously. She believed that they would be more useful when referring to them in future when that topic is taught again.

One teacher stated, "Each reflection has a goal of what I wish to change or improve the next time that I teach it. I believe that this has also improved student engagement and mindset as I am constantly reviewing my processes and pedagogy." The notes in my reflective journal have become more detailed and include ways to improve the lesson the next time I need to present the same topic.

Through sharing this knowledge from their reflections, teachers were able to learn from each other.

Example: One of the teachers kept an exercise book that replicated the student workbooks and it improved her reflections because she had the lesson plan and resources together in one place. The other teachers have adapted this idea to better suit themselves.

- Improved knowledge and understanding

Teacher knowledge was gained through academic reading, online resources and peer sharing. The researchers were all able to testify that they had increased their knowledge and expertise in a number of areas during their involvement in this project. This included knowledge about reflective practice, action research, problem solving strategies and HOTS. Also included was growing knowledge about functioning in a Professional Learning Community (PLC) at school. Teachers have also increased their awareness of the Marzano Design Questions and refer to this frequently when seeking new ways for students to engage with materials.

- Teachers were able to generalize their learning to other subject areas

Teachers were using what they had learnt from their reflective practice during this project in other areas of their work at school.

Example: One of the teachers began using more visual representations when introducing or reviewing materials. Although aware of the need to present information in as many ways as possible, this teacher was more conscious doing this because she felt more in touch with needs of individual students. She makes greater use of anchor charts and pictorial word walls in her classroom.

Teachers have begun to consciously reflect on their teaching practice in other curriculum areas as well.

For example, one teacher stated, “In Science, I have started keeping a journal and reflecting on what worked well and what didn’t work so well. I find I am more aware of what is going on throughout the lesson as I watch to see if the students are working towards the goals set”.

b) Students

- Talking mathematically

(Insert video of students talking about their 'Dice Train' Task).

Throughout this process, one of the goals and regular reflections has been about encouraging students to immerse themselves in mathematical language. On the 6th of May, 2015 the following reflection was recorded: "The students still had some difficulty justifying their responses and using mathematical language in their responses to the questions posed. My goal is to have more explicit teaching of justification using mathematical language". The students continue to receive explicit teaching around the use of mathematical language. The researcher hopes that by the time the students reach Year 6, using common mathematical language will be an automatic process. It was found that students were communicating mathematically more freely and their answers were becoming more succinct.

(Insert an example from last test on percentages.)

- Students using ranking scales to monitor progress in learning

  An important element of the Marzano Pedagogical Framework used in this college is the ranking scales in every classroom that help students to rate their learning progress. In a reflection from the 23rd April, 2015, the students had a clear learning goal at the start of each lesson. For example, a learning goal for this lesson was for "students to discover which shapes they could draw from a given perimeter". The learning goal was firstly discussed as a class and then the students gave themselves a ranking of where they considered themselves against that learning goal. At the end of the lesson or when the concept had been taught, the students ranked themselves a second time. By doing this, the students were able to see whether they had improved or whether they needed more consolidation on the topic. This helps the teacher to be more focused on the students' learning needs.

  (Insert photo of learning goals student scale)

- Transference of skills from mathematics to other KLAs

As a result of teaching the students 'the process of solving problems', the students had become better at working through problems in other KLA's as well. One researcher noticed a particular change in their Geography, History and Scientific skills. They would also write the 4 step process in their books when working in these other KLA's.

- Students reflecting on their learning

  The students in the Year 6 Maths class had begun reflecting on their learning. Through this process, the students focussed on three main questions: 1)" what did I find difficult? 2) What did I learn? And 3) what will help me to improve?" They also reflected on what they already knew and how the teacher could better support them in their learning journey. Time constraints meant that the students were not able to reflect as often as desired but this would definitely be something to aim for next year.

- Girls achieving in Mathematics

There were more girls in the "upper" level Maths group in Year 6. This has led to a greater willingness of girls to work hard at Maths and not just see this subject as one for boys.

4. Physical

a) Teachers

- Time to meet became vital for sharing reflections. Impromptu meetings were frequent. Teachers worked hard to manage time effectively and juggle multiple commitments.
- Reorganising of timetables in order to create flexible student groups
- A PLT (Professional Learning Team) was created to facilitate the sharing of teacher reflections and shared teacher practice.
- Buy in from other staff. Other teachers were interested in knowing more about our project.
- We had the opportunity to present our findings to staff. Colleagues showed interest in what we were doing and how we were implementing our ideas. Anecdotal evidence revealed a flow-on effect, for example, the Year 2 teachers said that they were presenting their students with Maths problems and the students were deciding what knowledge they needed to undertake the activity. This was something that was shared at one of the presentations to the Junior School staff.

- PLTs at FLCR for these researchers included this TAR research team and the respective year level teams. Improved collaboration led to openness in communication with a greater willingness to try new instructional strategies and then assess on how successful it was.
- Colleagues willing to support each other with advice and respite when managing more challenging students.

b) Students

- Flexible Learning Groups- This year we chose to run 'Flexible Learning Groups' to better support the students according to their prior knowledge and learning styles. The groups were established based on pre-test data. The Year 5 and 6 teachers decided that based our observations from the project, something had to change with regard to the structure of pedagogy in mathematics. We needed to cater for the individual needs of the HA students more efficiently and effectively. According to this researcher's observations, the students were more likely to challenge each other and justify their reasoning when in smaller like-minded groups.

- Use of space (floor, soft furnishings, etc.)

The students worked in groups that were flexible and task dependent. The physical make-up of the group changed from time to time according to the mathematical topic. The students were encouraged to work in a space that enabled them to work comfortably. Group size varied according to the number of children present but the general consensus was that grouping children in 3's worked best.

E.g. Students worked outside measuring length, recording data as part of their task.

Students, when working on investigations or problems could choose to work where they wanted. They might select to work around tables, on the coffee table, on the floor or outside – the choice was theirs.

The teachers had in mind that they were preparing their students for Middle School where they would have different classes, different teachers and different locations for different subjects. The students needed to learn to be better organised and flexible.

The students became more interested in the open-ended problem solving questions. For example, a memorable success was when students, through their work on an open-ended data task, worked out for themselves the best types of graphs to use in

particular situations. They were prepared to do the more tedious paper and pencil worksheets at home to discuss in class the next morning so that the class could get on with the more interesting and challenging problem solving tasks in class.

The students were learning to share their mathematical thinking processes with their peers. In conjunction with the Marzano framework, the researchers found that even the students were more willing to reflect on their own learning. They were able to articulate where they were having success or difficulty on particular tasks.

There were two opportunities to share our learning enthusiastically with the other teachers during phase two. The teachers responded well and it opened channels of communication. There was also one opportunity to observe the teachers and students in each of our project classes and provide feedback. This proved to be a positive experience (even if a little nerve-wracking!)

CHALLENGES TO OVERCOME

Time! It remained a challenge to have sufficient time to reflect, to record data, to stop and think…..to realise where to go next….. Having time having time to undertake this project; time to write as much in our reflections as we would like. Having sufficient time to properly analyse and share our findings at a group level. Having sufficient classroom teaching time that includes problem solving with HOTS as well as teaching other curriculum skills remains important. “I have tried to re-organise my timetable to ensure I have time with my high achieving students. This sometimes requires parent helpers or Teacher Assistants to help the other children.”

It was a challenge to keep up the teaching of general Math’s skills, making sure that the students were exposed to all of the concepts that would be tested across the year level, e.g. “I had a failure with that this week, because I had not explicitly taught a particular concept and students failed to notice it during a grade level assessment.”

Experiencing reflective practice as a team activity and not just as an individual teacher was essential. Transitioning from individual reflections and classroom practices to finding common themes as a group in our reflective practice is a current challenge. It was

difficult to be able to find common times for the whole group to meet as well as having sufficient time to prepare for meetings. Effective communication was necessary: staying on task and on topic during meetings to make the most of our meeting times.

By using guided practice, particularly in Year 4, students were able to learn how to read and analyse questions effectively and master a 4 step process of problem solving. This year the researcher's focus shifted from teaching problem solving strategies to working with students on the processes for problem solving. This researcher found that for some tasks (that may be more challenging and open-ended), the students worked best in a small group of between three and five. For problems that have an end point and only require a few steps in a logical sequence, this researcher found that working in pairs was the best formula. When there were more than two students working together on an easier task, it was found that there was always one that failed to participate. However, during more open-ended tasks, it was found that having three or more students encouraged higher-order discussions and even rebuttals.

Having a general class group for mathematics in Year 4, with a huge range of abilities meant that teaching time with the high achieving students was sometimes limited. However there was a large range of student abilities even within the HA groups in Years 5 and 6. There were students who were very driven and others who were just along for the ride. By journaling, I was able to monitor those students more effectively and found patterns in their behaviour. By changing the way that I was collecting my data helped to save time.

Having students in the class who were not all active participants in their learning was difficult. This was where enhancing student engagement also comes into play. Students required assistance to feel comfortable with using a concrete, practical or representational means to display their problem solving methods in support of their calculations. Students benefitted from help to develop a common language to describe their mathematical thinking as well as learning the vocabulary for HOTS. Collecting, storing, presenting and sharing usable qualitative data for this project was an enormous task. Working with qualitative data was new to this team who felt more comfortable with quantative data.

One researcher incorporated an element of problem solving into each lesson. This allowed them to reduce the amount of focussed time just on problem solving. A major change to the Year 5 and 6 teachers had to get to know some students from other classes. These students also had to get to know the teacher's teaching style. The challenge was to "teach" skills and then move on to open-ended problem solving tasks. Because the Year 6 teacher had to "keep pace" with her colleagues, she found that she wasn't able to spend extra time pursuing problem solving. This researcher resolved to spend less time teaching skills before the problem was given to the students. Once the students had some preliminary background, they were able to tackle the problem and the other skills could be taught simultaneously with the problem solving process. The students became more interested in the open-ended problem solving questions and learnt to determine which skills they needed to use for different question types.

CONCLUSION

In answering our research question:

How does developing reflective practice affect teacher pedagogy and influence student higher order problem solving in mathematics?

The researchers were convinced that the teacher reflections were in fact driving this project! Teacher instructional practice and pedagogy changed because of the teacher reflections. The evidence was clear that during this study, teachers' instructional practice improved on many levels such as:

- Using teacher reflections to guide new learning goals, change lesson plans, trial new teaching strategies or to inform other improvements in pedagogy
- Teacher reflections promoted careful observations of students' learning behaviours, strengths and weaknesses
- Teacher reflections enabled teachers to fine-tune their instructional practice to meet the needs of a particular group of students
- Through sharing teacher reflections in a collaborative team: a) teacher knowledge increased, b) a culture of trust and collegiality ensued, c) teacher

> confidence increased to trial new methods and d) teachers became motivated to improve their pedagogy.

Students consequently also benefitted from the changes that were made. These benefits included:

- A changed attitude towards problem solving in mathematics
- Increased confidence and willingness to take risks
- Decreased anxiety and fear of failure
- Improved persistence to complete challenging tasks
- Learning to talk "mathematically" while explaining their methods
- Improved attempts to think critically, analytically and ask questions
- Gaining confidence in presenting their ideas in front of peers
- Learning to work collaboratively in small groups

These researchers agreed that their teacher capacity grew as they were prepared to view their practice in an honest and critical way making changes as needed. They agreed with Rooney (2012) who stated that:

> The real success was in the journey and not the destination. In carrying out the research, I was compelled to look at myself and my practice, as a teacher with honesty (Rooney, 2012, p. 121).

As teachers we gained confidence through our personal professional learning journey discovering more about teaching problem solving strategies and HOTS, using open-ended questions and using flexible student groups. We were sharing and developing common language and teaching strategies for problem solving in mathematics. Through regular meetings and professional conversations we have also learned mutual trust and respect for each other. By reflecting on our pedagogy, we have been able to determine what works in the classroom and what doesn't. We were able to use these reflections to inform our teaching and were able to a see how the students responded with greater precision. Improved ways of recording in our journals by keeping planning, learning goals, teacher reflections and student responses together created an easy reference for sharing pedagogy and making improvements to future planning. Keeping a reflective journal which

outlined the learning goals (in conjunction with our work on Marzano), included an outline of the lesson taught, a reflection on pedagogy and how the students demonstrated their learning and a goal to work towards. Reflective journaling helped us to see how the class worked well; the type of content that students enjoyed and what engaged them. The way that lessons are structured has also changed as a result of our current reflections. Various forms of group dynamics were evaluated. How the students in the class best to responded to the task at hand was carefully observed. Teacher reflective practice followed immediately after lessons. The researchers found that they were challenging their instructional practice in all subject areas; not just in problem solving (i.e. this TAR project!)

FUTURE IMPLICATIONS

Establishing common norms for sharing reflective practice within professional learning community teams is advisable. The researchers have been investigating ways to refine the journaling process making it easier to combine planning, pedagogy and student responses together with our reflections. Organising written reflections under a structured format of headings would make it easier for teachers to share and track similar themes in our reflections. In this was a workable model for teacher reflective practice could be developed.

Observing and discussing instructional practice with peers is another learning experience that the researchers began to explore. Finding ways to give peer feedback on instructional practice through teacher observations would be beneficial. Difficulties because of the costliness of teacher release need to be overcome. Viewing video clips from the classroom during team discussions was considered a possible solution.

While reflective practice is beneficial for teachers, it can also assist students in understanding their learning processes. The researchers would like to assist students to express their mathematical processes in student journals becoming reflective in their learning.

It would be beneficial to compile a bank of strategies, readings and findings from this project for all staff to share. Collating problem solving activities suitable for a range of students at different levels would be helpful to all teachers. Developing a bank of suitable open-ended problem solving questions for teachers would also be beneficial. The

researchers have also discussed the usefulness of developing a system to rate the level of difficulty or type of HOTS required to solve particular problems. Also needed is a common mathematical language for expressing processes and strategies during the problem solving process. The researchers aimed to introduce more complex problems, i.e. 2-3 step problems for students to work through whilst still following the same framework. Students would be able to act as peer tutors for younger children or cross-grade classes to extend the 'Problem Solving Culture'.

The researchers agreed that changes on a whole school level are needed with regard to the way higher-order problem solving skills are taught in Mathematics. As a sequential systematic uniform way of introducing mathematical thinking, mathematical language and problem solving processes in our college has not been implemented. The process by which that goal will be attained remains a matter for further consideration. The researchers would like to see our team have further opportunities to share about reflective practice and how it has helped us to refine our teaching and inform future planning with colleagues across the Junior School.

What we do know is that in order to foster higher-order thinking skills in our students we need to create a higher-order thinking and problem solving culture in our classrooms. In order to create a higher-order thinking and problem solving culture in our classrooms we, as teachers, need to become critical, systematic, reflective and creative thinkers in our teaching practice. Developing a culture of teacher reflective practice is a valuable step in the right direction.

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