Working Through the Practice Architectures of First Year University Mathematics Teaching

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This paper describes how a group of university lecturers are adopting an action research approach to improve the learning experience of students in first year mathematics. Using the three categories of saying/thinking, doing, and relating (Kemmis, 2009) to explore practice, it describes the new practices of the action research team, the established practices of mathematics teaching at university, and the team's trials at changing elements of that teaching practice.

There are compelling reasons for improving the mathematics learning experience of university students. Since the 1990s, in Australia and elsewhere, there has been a decline in students undertaking university mathematics (Nardi, 2008). In response, mathematicians are developing more interest in the way they teach. The first year experience is particularly important because it constitutes the transition from school to university mathematics. In this paper, we reflect on the first 18 months of our grass roots attempt as members of an action research team to improve first year mathematics at our university.

The action research approach we use involves undertaking repeated cycles of planning, acting, observing, and reflecting (McTaggart, 1997). In acting and interacting together for a common purpose over an extended period of time, we have formed a community of practice (Wenger, 1998) which we call the Mathematics Action Research Team (MathsART). However, following the action research model does not necessarily guarantee success. Neither MathsART nor its members is context free; both are embedded in larger communities of practice. In our case, MathsART is located in the Discipline of Mathematics within the School of Engineering and Physical Sciences at James Cook University. These larger entities have what Kemmis (2009, p.466) calls "practice architectures" that are the "mediating preconditions" which "shape and give content" to how we talk/think, act, and relate. The challenge for MathsART is to influence the established "practice architectures" to produce better teaching and learning.

In this paper we describe three sites of practice: the emerging practices of MathsART; the established practice architectures of the Discipline; and the changes that MathsART has trialled in the two first year mathematics subjects. For our analysis, we have revisited the written summaries of our meetings and our recorded conversations. Through a process of consensus we arrived at key elements in the "saying, doing and relating" (Kemmis, 2009, p. 466) of each set of practices.

The Practices of MathsART

In July 2010, the Head of Mathematics (Shaun) organised a workshop for the six mathematics teaching staff and the secondary mathematics education lecturer (Jo) to discuss the teaching and learning of mathematics particularly in first year. In the previous semester, the pattern of high failure rate and low tutorial attendance had continued. Furthermore, in an informal survey of the first semester cohort, only 17% had indicated that they had spent, on average, at least the recommended minimum of six-seven hours of home study each week. Jo's concern centred on the higher than average failure rate amongst the small number of education students. These students constitute fewer than 5% of the total cohort of

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approximately 200 students who are mostly engineering and science undergraduates. Shortly after the workshop, the action research team was formed.

The four core members of MathsART are three mathematics lecturers (Patrick, Shaun and Wayne) and one mathematics education lecturer (Jo). The three mathematics lecturers have extensive experience teaching mathematics (over 10, 20 and 30 years respectively) including in the first and second years. Jo is the facilitator in the action research team. Her expertise is in adult learning and in using action research to generate change in professional practice. She teaches secondary mathematics education in the School of Education.

The common purpose of the team members is to increase the quality of the student learning in first year so that more students succeed in the two subjects and, as importantly, carry a deeper understanding of mathematics into their second year. The project began with attempting to increase student engagement.

Action research aims to change "practitioners' practices, their understandings of their practices and the conditions in which they practise" (Kemmis, 2009, p. 463). Accordingly, we are developing norms concerning the talk we engage in, the work we do, and the way we relate to one another. Table 1 below summarises the main practices we are developing.

Table 1
Ways of Talking, Doing and Relating in MathsART

Developing Practice	Adopting different ways of thinking/acting/interacting
Saying/thinking	Fostering the belief that pedagogy can make a difference
	Deprivatising practice
	Decision-making based on evidence
Doing	Implementing the action research cycle
	Weekly professional conversations (audio-recorded and minuted)
	Reading literature on pedagogy and sharing reflections
	Posting reflections about teaching on the community website
	Professional development (PD) with school teacher on ICTs
	PD with school teacher on school curriculum and assessment
	Doing research on our practice for wider professional community
Relating	Peer observations of teaching
	Incidental conversations about teaching with peers

The Practice Architectures of the Discipline

In Table 2 we list what we believe are some of the key aspects of the entrenched practice architectures defining how mathematics has been traditionally taught at this university. The table is purely descriptive and provides no explanation for why the practice architectures have formed in the way they have.

Actions Taken to Improve Mathematics Teaching and Learning

Despite being immersed within the practice architectures described in Table 2, MathsART has implemented a range of different practices in their teaching. Some of the more significant actions trialled are listed in Table 3.

Table 2
Practice Architectures of the Mathematics Community of Practice as at July 2010

Practice architecture	Examples
Saying/thinking	
About the learner	Student performance has declined since the 1990s. Student results are primarily a function of students' ability, background knowledge and application. The school system is the main source of the problem (Belward, Mullamphy, Read & Sneddon, 2007).
About the teaching	Content and pedagogy in first year mathematics are not the cause of the problem but need to change because of the problem. Content is more important than pedagogy
	Staff see themselves as mathematicians first, teachers second.
	Pedagogy is not generally understood and is not a priority.
Doing	
Lecturing	Transmission approach
Tutorials	Traditional – students arrive with problems and tutor answers them
Assessment	Online quizzes; on-course and final exams; no calculators
Resources	Lecture notes, tutorial sheets and solutions - the same year to year
Tutors	Generally postgraduate students with no training in teaching
Relating	
Student/student	No peer collaborative work done
Student/lecturer	Little subject specific feedback sought
Lecturer/lecturer	Lecturer works autonomously; conversations on teaching are rare

Table 3
Actions Taken by MathsART over the 18-Month Period of Operation

Elements of practice	Actions taken or implemented
Saying/thinking	As for Table 1
Doing	
Lecturing approach	Interactive approach trialled
Tutorials	Structure encourages interaction; attendance monitored[1]
Assessment	Now offers students a "second chance"
Resources	Tutorial exercises revised; online quizzes evaluated[2];
Staffing	Lecturers tutor; School teacher tutors preservice teachers
Students	Feedback sought regularly; Hons research projects on first year
Relating	
Student/student	Collaborative learning arrangements outside of class[3]
Student/lecturer	Tutorial representative meetings with staff
Lecturer/lecturer	Working collaboratively on subject design

[1]Note: Higgins's paper reports on tutorial attendance rates. [2]Note: Read's paper reports on the evaluation of the online quizzes. [3]Note: Belward's paper analyses lecturers' response to feedback on this initiative.

In Conclusion

The analytical descriptions provided have deliberately limited themselves to identifying ways that contrast the practices initiated by the action research team with the existing practices of the Discipline of Mathematics. The descriptions do not include the large number of elements that remain the same in the action research community of practice and in the Discipline. For example, the structural element of three or four contact hours weekly is one element of practice that is the same. Another is the time allocation to the lecture mode of delivery and to the tutorial. The latter may change at a later date but for now, it is another constant. In the 18 months that MathsART has been working together, the mathematics lecturers in the team taught one first year subject twice and the other once. It would be naïve to suggest that MathsART has changed the practice architectures in the Discipline, practices that have accreted over many decades. Nevertheless, there are promising signs that change might occur. Other academics within the School have expressed an interest in the action research project and some even expressed a desire to join. Also promising is that new "meta-practices"—practices that Kemmis (2008, p.21) alerts us about—at the university level appear to be supporting our attempts at transformation. For example, the peer review process that we undertook voluntarily has become, in 2012, university policy. Most promising of all, the four members of the team wish to continue with the project. We give three main reasons for doing so. Firstly, we are confident that the action research process is a systematic and robust way to guide change in practice; secondly, we are confident from the evidence we have that the changes that are in train are leading to better pedagogy and better student results; and finally, we know that the job is not yet done.

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