Research into research on adults in Bridging Mathematics: the past, the present and the future

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Bridging Mathematics has been an informal network of researchers and practitioners from Australian, New Zealand, Southern Africa and the Pacific since the late 1980s. The political and educational climate that saw the rise of the network in those early years is not the climate that exists today. However, although the change in climate has effected both the research and teaching practice of its members, fundamental issues related to adults learning mathematics in all its forms are still being discussed. In this paper we will trace the history of research into and about adults in bridging mathematics highlighting the major achievements along the way. The recurring questions about 'What do we teach?', 'How do we teach it?', 'Who will teach it?' and 'What do we do about the changing technologies?' will be revisited, leading up to the final question – 'Is bridging mathematics still necessary?

Any form of effective mathematics teaching is underpinned by research and scholarship and enhanced by the development of a community of practice that will support and develop its members. This paper will trace the history of the Bridging Mathematics Network (BMN), an Australasian based informal group of practitioners, as it struggles to understand the nature of learning and teaching of mathematics to adults within the bridging context. It will investigate, 'What is the Bridging Mathematics Network?', its beginnings and initial research objectives, changes that took place between 1993 and 2004 in terms of research and the socio-educational climate over those years, the present and the future. During this journey the aim is to answer the questions:

- What do we teach?
- How do we teach it?
- Who will teach it?
- What do we do about the changing technologies?

culminating in the question "Is Bridging Mathematics still necessary in 2005 and beyond".

The why, who and what of Bridging Mathematics

The network was established in 1991 to provide a support group for all teachers of bridging mathematics and statistics, and to allow and encourage practitioners and researchers to share ideas and findings. Its creation was in response to the increasing number of bridging mathematics programs created in the late 1980s when drastic changes were made to government policies for Higher Education.

Initially, policies focused on increasing the overall participation in Higher Education and were driven by an economic imperative as a 'means of making Australia more productive' (Karmel, 1995, p. 25). In particular, mathematics, science and technology were seen as important components for this success. In the second Bridging Maths Network conference the then Minister for Education, Ross Free, stated that 'mathematics is probably the single most important area of study' (Free, 1992). By the mid-1980s the *Higher Education Equity Program* was established to fund universities to improve student diversity. However, in a recent overview of Access and Equity policy and practice in Australia James et al. (2004) indicated that the lack of success of this initial initiative lead the government in introduce a policy entitled *A Fair Chance for All* (DEET, 1990), which proposed to change the composition of the student population in Higher Education to reflect more closely the composition of society as a whole. Thus universities, with access to targeted funding, formalised access and equity planning and reporting mechanisms. For Bridging Mathematics this meant the development of programs to service and support students who previously had little chance of accessing university studies. For example, in 1994, 23 (of 35) Australian universities reported some form of bridging program and/or 'Learning Centre' which included mathematics support (Postle et al., 1995, p. 131).

Since the establishment of the Network, members have come from a variety of Australian and New Zealand institutions and taught in a variety of settings. They ranged from university lecturers involved in teaching first year or pre-tertiary mathematics courses, to those involved in teaching numeracy skills to industrial workers. In a survey of Australian University web sites Taylor (1999) found that organisational structures emerged from three sources. If the need was perceived in undergraduate mathematics, staff would most likely be located in a Mathematics Department (40% of cases). If the need was perceived by study skills or counselling staff then the staff were originally located in Student Services types of structures (30% of cases). At times a dedicated stand-alone section, such as a 'Mathematics Learning Centre' may have been established with line responsibility to a nominated Academic Manager (12% of cases). If the need emerged from industry, staff would probably be located in TAFE colleges. Today mathematics support is dispersed across a variety of Australian university structures.

Specific Bridging Mathematics courses were usually of two types: pre-tertiary stand-alone courses and in-context support. Much of the work of bridging mathematics practitioners is not documented nor are preparatory programs for Australian residents regulated or scrutinised. Each university sets up and manages it programs at its own discretion, resulting in a wide diversity of programs and approaches (Clarke, Bull & Clarke, 2004). Within the pre-tertiary courses, the number and type of courses are diverse (Cobbin et al., 1994). In contrast, Australian preparatory programs for international students (ELICOS and Foundation courses) are heavily regulated and accredited by the National English Language Teaching Accreditation Scheme (NEAS). So while standardised programs and accredited teachers for international students are the norm, preparatory programs for domestic students have no such imposed standards. For Example, Clarke, Bull and Clarke (2004) indicate that preparatory programs for Australian residents

- extend from 1 week to 2 semesters
- include a variety of curriculum designs (some do not include mathematics);
- include a variety of deliveries (face-to-face, distance);
- have assessment that varies from formal through to less formal or ungraded assessment;
- target different groups and disciplines; and
- issue a variety of certificates from a simple informal certificate of completion to a formal Certificate or Diploma award.

While bridging mathematics certainly flourished in the 1990s there was little community voice either within the institutions or outside them.

> … it was apparent that even within the one institution, many staff were not aware of their institution's preparatory programs, or were misinformed about prerequisites or the undergraduate programs which accept this entry method. In many instances, this state of affairs existed despite repeated attempts by relevant staff to keep others informed. … many academic and non-academic staff alike are unaware of the exact target and purpose of such [Access and Equity] programs offered by their own university. This internal lack of awareness of programs also contributes to problems in gaining uniform recognised guidelines across all faculties within any one institution. (Cobbin, Barlow & Gostelow, 1993, para 2)

The Bridging Mathematics community were certainly aware of this and worked for change. In 1992 BMN national coordination aimed to develop:

- Australian Bridging Mathematics Network
- National Resource and Materials database
- National Maths Support Service survey
- National Maths Bridging Course survey

BMN research to date

From the earliest days in 1992, to support their development, the Bridging Mathematics Network proposed a research agenda which aimed to look at a wide range of topics specifically aimed at the community of students we knew so well

- Ways of overcoming maths anxietyHelping students for whom English is a 2nd language
- Organising group work

- Using technology
- Tests and other methods of establishing student needs
- Using writing to learn maths
- Helping students to develop a maths learning set
- What are the important cognitive differences between bridging maths & traditional teaching
- Are bridging courses working? How to measure the success of our work?

To determine if the Bridging Mathematics Network had been successful in achieving its research goals and to answer the questions set at the commencement of this paper, conference participation and conference proceedings were analysed. Trends in Bridging Mathematics conferences, since their inception in 1992, were viewed in terms of conference participation and in the number and nature of the papers included within the conference proceedings (Figure 1).

Figure 1 indicates that participation has varied over the years. The lows that occurred in 1995, 1996 and 2000 were usually associated with the location of the conference away from major centres of population (eg Darwin, Adelaide and Perth). However, conference attendance has never reached its early high, when the climate within the Australian sector in particular was flush with concepts of access and equity. Production of papers has been reasonably constant between 1992 and 2002.

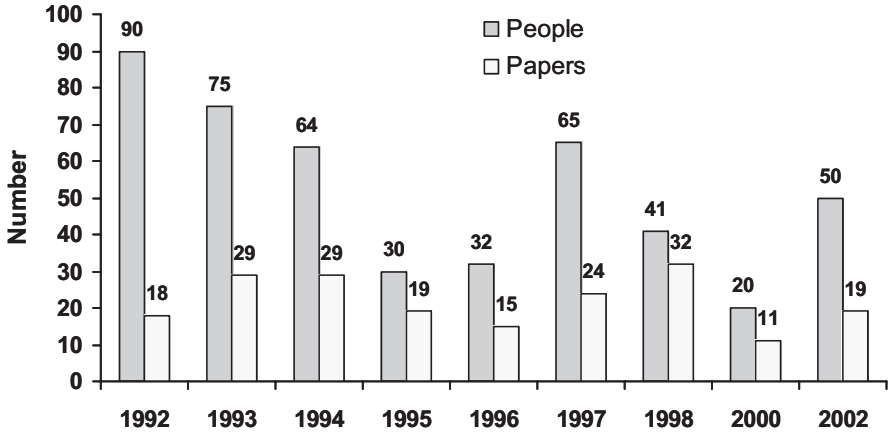

Figure 1. Level of participation at BMN conferences between 1992 and 2002 as presented by number of people attending and number of papers in the conference proceedings

Conference proceedings were analysed using a grounded theory methodology (Schatzman & Strauss, 1973) whereby all conference papers were assessed to determine what categories of paper emerged from the proceedings. On the basis of this, papers were divided into topics about courses (curriculum design, teaching practices, teaching problem solutions etc), research or technology. In Figure 2 it is clear that by far the majority of papers are about teaching and practice within Bridging Mathematics.

These papers were primarily descriptive in their nature and constituted approximately 44% of 196 papers presented between 1992 and 2002. These papers were usually descriptions of practice within a mathematics learning centre or the design of a new program, for example, to assist nursing students with drug calculations, or to describe a new video or software.

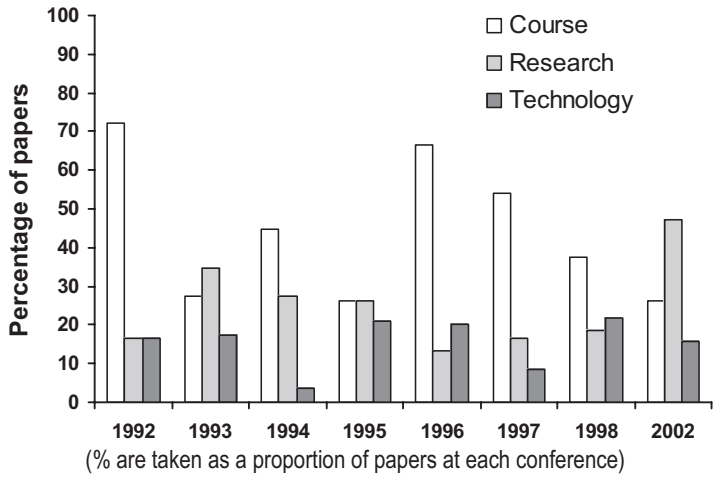

Figure 2. Percentage of papers from Bridging Mathematics Proceedings between 1992 and 2002 which match designated categories

Technology has been a consistent point of discussion within the Bridging Mathematics Network with 14% of papers focusing on this topic. These have been primarily involved with the introduction of graphics calculators, but there are others related to computer-based testing or the evaluation of new software or videos.

Research has been a significant part (26%) of the 196 papers. The nature of the research undertaken was described by using categories developed from the papers. The methodologies used in the papers were also noted.

Table 1 summarises the number and types of research papers. As the bulk of conference papers were about courses and activities it is not surprising that many research papers were involved with course evaluation. The other predominant topic involved background factors again unsurprising because of the strong focus on practice and curriculum design. Many of these papers investigated age, gender, previous maths background, learning styles or attitude to mathematics. In some rare instances, attempts have been made to develop predictive models based on these background factors. The third category of research paper was entitled 'learning'. In these papers, aspects of how students learn or study was investigated rather than general teaching practice. In most instances papers have used descriptive types of research methodologies, so surveys, interviews, observations and case studies predominated. With the exception of one or two, theoretical frameworks rarely underpinned the described research.

Table 1. Categories of research papers in BMN Conference Proceedings 1992-2002

Category of research	Number of papers	Example
Course Evaluation	12	Preliminary phase of the evaluation of a bridging mathematics unit (Mohr, 1998)
Background Factors	13	Mathematics support for tertiary students: an outline of backgrounds, needs and attendance patterns (Gillies, 1993)
Learning	15	Attaining the balance between learning the statistics discipline's content and processes and learning how to learn (Porter, 1995)
Policy	3	A survey of numeracy concerns at the University of Adelaide (Cousins, 1996)

If the investigation of the research papers is refocussed to determine if the original research questions posed in 1992 have been answered, it can be seen that attempts have been made on many of these questions (Table 2). However, five out of the original nine questions have been rarely addressed. The research conducted by Bridging Mathematics Network members can be benchmarked against that described with the Mathematics Education Research Group of

Australasia (MERGA) where Walshaw and Anthony (2004), in an analysis of MERGA conference proceedings, found a rich framework of mathematics and education topics and methodologies.

Bridging Mathematics Network, of course, is not an established organisation like MERGA, but why is the research not as rich? One hypothesis is that it results from the fact that overall, adults learning mathematics is an under theorised area 'which needs to draw upon as many relevant disciplines as possible in order to develop' (Wedege, Benn & Maasz, 1999). In 1990 Galbraith thought it was primarily a result of isolation and lack of connection with a research culture or partnerships, stating that a:

> …major concern was that educators in this field have had minimal liaison with their peers, and thus have individually concentrated on similar levels of work. They have thus proceeded without the advantage of a more powerful, more comprehensive, joint research and development base (cited in Godden, 1993).

Further Godden and Pegg (1993) thought that problems lay in evaluation methods and concluded that:

> the strength of bridging mathematics programs, their great flexibility and student-centredness, was the very reason they were unable to be evaluated in the traditional manner of educational programmes generally; they called for a new approach to evaluation in this important area (cited in Coben et al., 2000, p. 30)

Table 2. Number of papers in BMN Conference Proceedings between 1992-2003 which match the research questions posed in 1992.

Research Questions	Number of papers
Ways of overcoming maths anxiety	14
What are the important cognitive differences between bridging maths & traditional teaching	14
Tests & other methods of establishing student needs	13
Are bridging courses working? How to measure the success of out work?	12
Helping students for whom English is a 2nd language	2
Using technology	2
Organising group work	1
Using writing to learn maths	1
How do you define success	0
Helping students to develop a maths learning set	0

Cobbin et al. (1993) reached the same conclusion for research in equity studies. It is interesting to note that in a recent book on the evaluation of learning support programs only one section referred to the evaluation of mathematics-based programs (Webb & McLean, 2002). So research is difficult to practice in this area of bridging mathematics learning and teaching but are there political, social or educational factors which impact on research practice?

Why BMN is still needed?

As the network is a bridge to Higher Education it needs to keep abreast of practice and trends both in schools and at university to ensure its practitioners are informed of curriculum change in both sectors and can be reactive and proactive to change. Some Queensland data exemplify trends in the secondary-tertiary interface. Figure 3 shows the school mathematics enrolment patterns of Queensland students from 1996 to 2004 as a percentage of total senior certificates issued. While Mathematics A, (general mathematics course with little algebra) numbers have remained steady, both Mathematics B (a calculus based mathematics course) and C (specialist mathematic course which builds on skills and concept of Maths B) numbers have declined. The International Centre of Excellence for Education in Mathematics (ICE–EM) is investigating in detail national enrolment patterns in Australian final years of school (Year 11 and 12; AMSI, 2005).

A similar trend in enrolment patterns may be occurring within Bridging Mathematics courses. At the University of Southern Queensland (USQ) Toowoomba, Australia for example, students in the Tertiary Preparation Program (TPP) are continuing to enrol in mathematics.

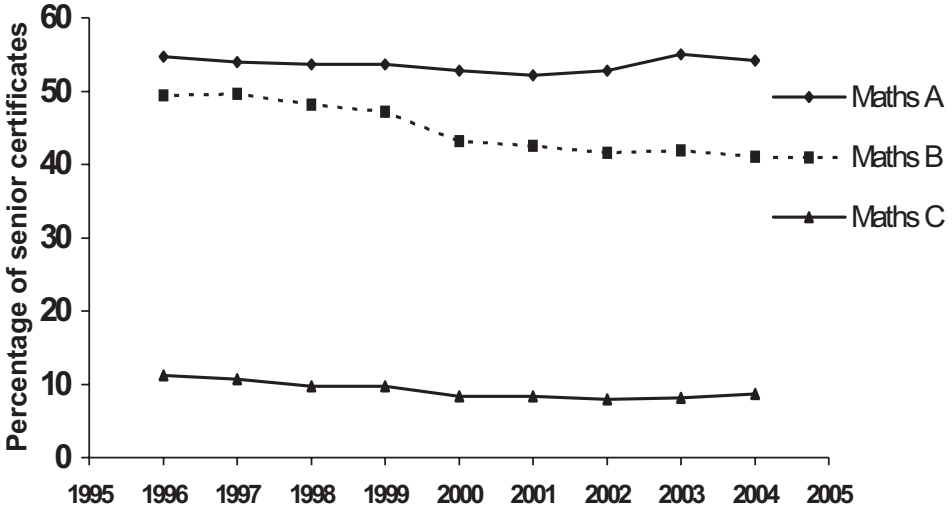

Figure 3. Queensland Mathematics Yr 12 enrolment 1996 - 2004 compared to certificates issued

However, Figure 4 indicates that most students participate in our lowest level of mathematics (TPP81). What appears to be happening in both the school and bridging mathematics sector is that students are still doing some mathematics but often at a lower level than the demands placed on them at university.

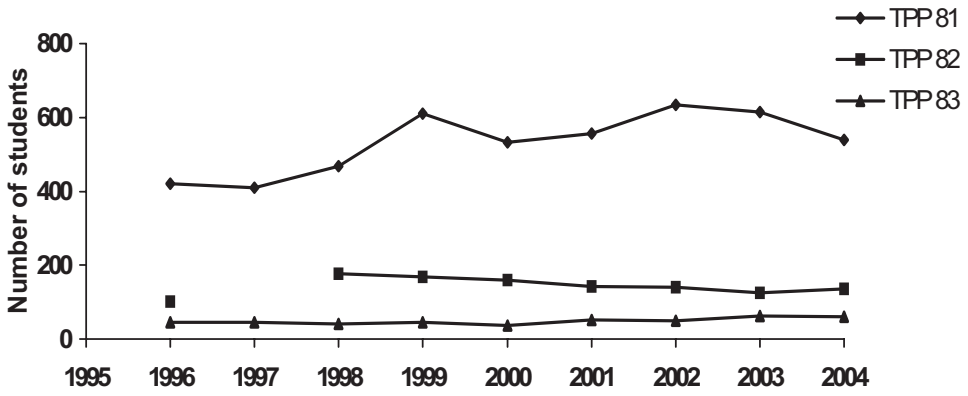

Figure 4. Number of students with final grade in the USQ Tertiary Preparation Program

For example, while Mathematics C is not listed as a prerequisite at the USQ for students entering a Bachelor of Engineering degree, it is useful, and perhaps is an expectation of some lecturers. Figure 5 shows that in 1997, the majority of students had completed Mathematics C prior to university studies and thus thought it was useful although not required. However, the numbers declined steadily from a high of 82% in 1997 to just 35% in 2002. This does not necessarily mean that students will not be successful at university, but rather that their first year may be more demanding and support services needed more extensively to bridge the gap.

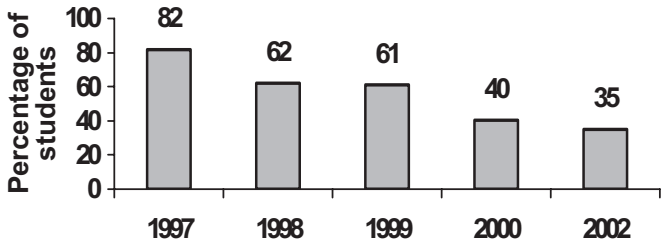

Figure 5. Number of students who have studied Maths C in Engineering

It is not only mathematics and science based courses where the support is needed. There are also many courses traditionally believed to be 'non-mathematical' where a level of academic numeracy is assumed. In a survey of all first year courses at USQ, Taylor et al. (1997) asked first year lecturers what mathematics they believed was needed in their respective university courses (Table 3). It was apparent that the stated entry requirements for many programs do not match the lecturers' expectations of the mathematical knowledge required within their courses. For example, in a business degree, economics lecturers expected students to have completed school Mathematics B, while the entry requirements stated pre-requisites made no mention of this.

Table 3. Mathematics background expected for courses within each Faculty

Faculty	*None*	*Year 10*	*Maths A*	*Maths B*	*Maths C*
Commerce	*Introduction to Law*		*Introduction to Accounting*		
Business	*Australian Political Institution*			*Economics*	
Sciences	*Data Analysis*	*Foundation Psychology*	*Organic Chemistry*	*Foundation Chemistry*	
Engineering	*Electronic Workshop*		*Engineering Communic-ation*	*Civil Eng Materials*	*Electrical Technology*
Education	*Foundation of Language*		*Socio-Cultural Physiology of Educ. & Sport*		
Arts	*Communication and Scholarship*	*Intro. to Studio Practice*	*Voice and Movement*		

Conclusion

So in summary what can be said about bridging mathematics, its past and its future? Today bridging mathematics programs are many and diverse, yet staff in these programs are often still marginalised within the Australian Higher Education sector. The status of mathematics within schools and universities is at a low with many students opting to study easier types of mathematics, universities removing mathematical pre-requisites from award programs and not recognising the embedded mathematics within many of their courses. These trends ensure that initiatives which allow students to bridge the mathematical gaps to university are still necessary. Yet the current social, economic and political climate is very different in Australia today compared to what it was in 1990s. Many practitioners fear that the economic rationalist approaches adopted by current government may make provision of bridging programs, although still necessary, more difficult.

On the research front, bridging mathematics research does exist, although even after 10 years of progress it is still in it infancy, with many authors not making the jump to peer reviewed publications, it has shed some light on who we teach, what we teach and how we teach it. However, there are many questions not fully answered and as universities move into the culture of quality and performance matched funding, it is essential that we continue to address the following questions.

- **How is success defined in bridging mathematics activities?**

  Practitioners must record, monitor and benchmark access, participation, retention and completion of students within their initiatives, at the same time as other qualitative measures of success such as career control, self esteem and goal setting.

- **What are the numeracy demands on entry to 'non-mathematical' university study?**
  Investigation needs to continue into what mathematical knowledge and skills are required in first year university courses, especially those which are reviewed as 'non-mathematical'.
- **What are effective ways to support that study?**
  Practitioners often believe intuitively that their initiatives are successful, but have we the quantitative measures that address both educational questions and cost effectiveness questions?
- **Are successful bridging students successful university students?**
  Have there been any studies that rigorously investigate whether students who complete bridging programs are successful in university studies?
- **Is there more than mathematics?**
  Mathematics is often seen as a set of skills independent of all other skills. Have there been any studies which investigate the development of mathematics skills with other skills believed necessary for success at university. Are these built into our bridging programs?

In conclusion, we hope that we have provided evidence that bridging mathematics is still an essential activity within the Australian Higher Education sector and staff must have the brief not only to teach, but to research their students' learning and performance before, during and after completing bridging mathematics initiatives. It is important that all who are involved in bridging mathematics:

- actively campaign the importance of academic numeracy skills in all university programs;
- continue to quantify, qualify and write about current practice; and
- rigorously defend the notion that bridging mathematics is an academic activity.

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