Mathematics in school and community in the primary years: possible effects on choosing engineering as a career

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This paper draws on the findings from an Australian national survey of partnerships between schools, homes and communities to improve children's numeracy. While such partnerships are routinely touted as important tools in promoting more engagement with mathematics and better mathematics outcomes, in fact they face many hurdles. We describe some of the successes and problems of such programs and consider the likely impact of children's early experiences of mathematics on career choice. We argue that when parents are ambivalent at best about their own uses and knowledge of mathematics and children see little relevance of mathematics curricula to their own lives, there is likely to be disengagement. This of course is fatal to any future adoption of engineering as a career. Calls to push the acquisition of basic knowledges further and further back in the education system so as to increase undergraduate enrolment in engineering must take account of the whole socio-cultural situation and not just classroom and curricula.

Introduction: Mathematics education and career choice

As the conference theme acknowledges, career decisions can be influenced by choices made and attitudes developed quite early in life. As far as engineering is concerned, some able students may be barred from entry into undergraduate programs because they have not chosen the approved mathematics and science subjects at school. Mathematics is often seen as a 'hard' or 'nerdy' subject and attitudes such as these, rather than aptitude or acheivement, can lead to students being put off developing the serious interest in mathematics that is necessary for those seeking to enter engineering. These negative attitudes can be acquired very early in a child's schooling and are not uncommonly reinforced by negative attitudes held by parents. It is therefore important to understand something of how these attitudes are formed and reinforce each other in order to comprehensively address the issue of the recruitment of suitable students into engineering.

Drawing on several case studies which formed part of a national survey of numeracy practices, we argue that better alignment of community and home understandings of the uses of mathematics with school-based practices results in more positive attitudes to mathematics learning and that this has the potential to revolutionise engineering education.

Methods: Choosing Case Studies

This paper draws on the findings from a national study funded by the Department of Education, Science and Training and carried out by the University of Queensland which examined *Home, School and Community Partnerships to Support Children's Numeracy*[1]. Its design consisted of three phases:

- a questionnaire survey of education organizations, parent and community groups, and an email survey of primary school Principals throughout Australia;
- interviews with key personnel in State and Territory Education Departments, Catholic Education Commissions/Offices, and Associations of Independent Schools;
- case studies of exemplary, sustained numeracy programs featuring home, school, and community partnerships.

Cases were selected from analysis of the questionnaire and interview data so as to sample a range of partnership initiation strategies, partnership dimensions, numeracy practices, target groups of educationally disadvantaged students, and geographical locations. Visits to each case study site lasted 3-6 days and involved: observation of classrooms, school staffrooms, teacher-parent interactions, and families in their homes; interviews with teachers, school administrators and support staff, and parents; and analysis of teaching materials, policy documents, and evaluation reports.

Three case studies, in particular, have been chosen for this paper to illustrate the ways in which the relationship between school and home/community practices of and attitudes to mathematics may impact on student interest in the subject. The Mobile Pre-School Pilot Program (MPPP) is a 'top-supported' partnership, in which the education system represents the 'top'. It operates in remote Aboriginal communities and cannot do so without community support although the curriculum and teaching materials take little direct account of cultural specificity. In general, top-supported, as distinct from top-down, partnerships showed a much wider spread of activities across school, home and community settings. Also, there was much more evidence of innovative teaching and learning approaches in such partnerships. Doing mathematics in home and community settings, using teaching methods that specifically relate the tasks at hand to the setting is more likely to develop a responsive attitude in students.

The Perth Primary School mathematics program operates as a combined school- and home-generated partnership that serves the schools' own population of students and their families, focussing on schooled numeracy practices through a mixture of innovative and conventional teaching approaches and resources. Family involvement is encouraged by teachers in this setting but little actually happens. This case study illustrates how excellent pedagogy and curriculum does not necessarily make up for negative attitudes at home in fostering student interest in mathematics.

The Distance Education Centre example from New South Wales constitutes a top-down partnership, focussing heavily on schooled numeracy practices through a highly structured, conventional curriculum. At the same time, the partnership was also in a sense generated by families who take a very active role in this form of schooling. These programs seemed to offer more scope than other top-down partnerships for family involvement in numeracy learning, and this was reflected in additional, innovative approaches to curriculum and mathematics practice. Of all our case studies this one showed the best 'fit' between family and school attitudes to and uses of mathematics.

Findings of the Study

Perth Primary School

This case study entailed examination of a primary school learning community, rather than a study of a well-defined program. This school demonstrated an integrated approach to numeracy education as far as classroom practice went and they had been successful in improving students' performance on standard benchmark tests. The approach had been informed by extensive previous experience of programs such as the Family Maths Program Australia (FAMPA)[2], but the emphasis was still largely on perfecting pedagogy and then explaining it to families, rather than using home attitudes and practices as the reference point.

The learning community's approach to numeracy emphasised the strategic use of mathematical knowledge, and active reflection on the application of concepts. This attention to process and reflection on learning exemplifies approaches advocated in the literature[3, 4, 5] which point to the significance of strategic and contextual knowledge and competencies in numerate practice. Within this framework, teachers encourage students to draw on their daily experience and past experience of mathematics, which allows more than one way of conceptualising and performing tasks. This practice is consistent across a number of settings in this school, including subject areas other than mathematics. Strategic application of mathematics was easier for teachers to handle in the classroom than extended contextualization, however, so that it was sometimes a struggle for students to really reflect effectively on the wider uses of what they were learning.

Parents were involved to some extent, via information and discussion sessions with teachers. The emphasis placed by teachers on 'mathematics in context' and strategic thinking, however, was often not matched by parents' understandings of mathematical education. Instead, there was a clear feeling from the parents that "drill and practice" learning, and additional homework, was a more valuable and valued way to accrue mathematical knowledge. Parents said this even when they also related that they themselves had been put off mathematics in school by just such uninteresting, rote learning. Students whose parents reported negative experiences of school mathematics were often reported by teachers to themselves have problems with mathematics. We contend that this illustrates that to make mathematics interesting to students, attention needs to be paid to parental attitude and involvement.

Distance Education Centre

The Distance Education Centre we studied was situated in rural New South Wales. This Centre was typical of most distance education services in that teachers at the Centre were provided with standard materials from a central publishing unit which they then could modify only slightly according to the needs of their students. Materials are sent out to homes where parents supervise the children's learning, and organise the home and its routines to make learning possible. They commonly are very active in this "supervisor" role, guiding children through the learning and finding ways to make links with everyday practice and experience which enhance its meaning. The following vignette is typical of many such experiences in distance education:

> **Jenny' story**
> In Jenny's first few months as a Supervisor she found it quite difficult to make connections between the prescribed mathematics program and her daughter's numeracy experiences. Jenny commented that it was difficult to motivate Jane to work on unit-based activities for more than ten minutes and was concerned that she was expected to focus on mathematics for 40 minutes per day. Although she felt that she should be providing Jane with a range of naturalistic experiences, both from "inside" and "outside" traditional classroom boundaries, to foster her love for learning, the school system was emphasising pencil-and-paper activities. Contact with a support group for parents with children in distance education exposed Jenny to new ways of thinking about mathematics and about fostering interest in it. She soon began to concentrate on 'mathematics-in-context', as part of everyday life and saw her daughter's motivation for and command of the subject increase markedly.

> Now Jenny confidently describes the extent to which Jane is using a range of numeracy skills when she helps her father build their mud-brick house. Importantly, she now attempts to modify and target specific unit-based activities to their personal home context and she endeavours to relate Jane's emerging number development to projects that are ongoing around the home Spatial understandings are related to the house building while measurement activities are linked to home cooking.

Many parents profess themselves lacking in confidence when it come to mathematical subjects and rely very heavily on teacher encouragement in applying the provided materials and developing them for their child. For these parents it seems to us almost impossible to instill a love of mathematics in their children. In this, they are a more obvious case of the situation described for the Perth school. Negative attitudes in parents, and/or little attention to mathematics in the home, are likely to impede the development of an interest in mathematics in the child. Some children may be being selected out of engineering as early as their very first years at school because of factors like this. Our next case study considers aspects of the situation of mathematics at the pre-school level.

Mobile Pre-school Pilot Program (MPPP)

The Mobile Pre-school Pilot Program develops pre-school programs and materials to distribute to children aged 3-5 years in isolated and remote locations in the Northern Territory. Materials consist of a variety of play activities designed to familiarise children with pre-numeracy and pre-literacy skills (Mobile Pre-school Pilot Program: Status Report, 2003, pp.2-3) but they are exactly the same materials used in metropolitan settings. For instance, the set of materials on a transport theme includes puzzles and books built around traffic flow and red busses – in communities that don't even have roads. It was the job of the local Teaching Support Officers to adapt the program for the week to immediate circumstances but rather than translate the materials into local terms we saw the teams working to explore the exotic nature of the world represented in these materials. Access to such communities can only be obtained with the support of everyone there and this clearly exists, because, we were told, community members were aware that their children needed a good familiarity with the whitefella world. The relevance of mathematics education, then, does not always lie in conformity with immediate experience. Here what was important was the ability to engage students and develop their skills through addressing their aspirations. The MPPP activities observed each developed mixtures of target mathematical knowledges and competencies identified by the National Mathematics Curriculum Profile. But developing knowledge is not enough if people don't know how to use it relative to context. This case study illustrates that the development of strategic and contextual mathematics abilities may be a quite complex matter – and of course engineering is a profession intimately concerned with the strategic application of mathematics in context.

Mathematics education, choice and "fit": implications for engineering education

There is a well established case that when school-based mathematics is related to out of school activities and interests, student engagement with the subject is enhanced[6, 7]. We also know that engineering students from non-Anglo-Saxon, non-middle class background and those who are female – that is everyone outside a narrow demographic with a particular worldview and epistemology – often struggle to meet the demands of an engineering education. This is not for lack of ability but because their ways of being in the world, their values and practices, are disallowed by narrowly focussed curricula and educational cultures[8]. They feel as though they do not 'fit' in engineering because their experience is not accounted for[9]. If we want more students to take up engineering at tertiary level, engagement must be

fostered from the earliest moments in the educational career, and in the home. Yet even excellent numeracy programs such as we have reviewed find this difficult to achieve.

While partnership approaches such as that in the Perth example may claim to give families and community members a greater opportunity to participate in the wide range of school involvement activities, parents' perspectives on family-school relations, parents' responsibility to instruction and the needs of diverse families as they establish their role in the partnership all seem to be taken for granted. Policies relating to the need for and implementation of partnerships, too, often overlook the relations of power between the school and the home and the tensions that arise from such relations. For instance, again in the Perth case study, a middle class school with a very successful and innovative mathematics program emphasised mathematical thinking and communication from the pre-school years in ways that ought to predispose the students to develop an easy fluency in mathematics and the ability to see its usefulness in everyday applications. In contrast to the classroom approach children experienced at school, we found that parents placed greater importance on acquiring mathematical knowledge via memorisation and "drill and practice" exercises than on developing strategic knowledge with problem solving tasks. Parents often expressed a lack of confidence with mathematics and a concern to understand what was taught at school so they could help their children at home, but all too often we found a situation of 'mixed messages' which ultimately contributed to declining interest in mathematics.

In comparison, the MPPP partnership was significant primarily for the success of its subtle articulation of school, home and community sectors in pursuit of better educational outcomes for the children. It demonstrated that essential relationships, such as those between "school staffs and families at home and at school"[10], cannot be mandated from outside nor built up overnight. Rather, they depend on trust and mutual respect which can only be demonstrated over time. While there is little direct data on the success of the partnership in preparing children for numeracy, due to the program's relatively short duration, anecdotal evidence and relevant literature suggest that it aligns successfully with the move to a family-centred perspective in numeracy learning[11], in which the influence of parents or significant others is seen as critical in children's development of mathematics practices[2, 12, 13, 14, 15, 16]. Further, a commitment to making use of the funds of knowledge in homes and communities[17], acceptance of the value of home numeracy practices, and investing resources and energy into identifying and understanding such funds of knowledge both in and out of school experiences have provided for a seemingly better 'fit' between stakeholders' understandings, curriculum, and practice in this partnership. The 'fit' here was not one of identity but of negotiated goal-sharing with parents supporting the importance of mathematical learning in the whitefella way but also making sure the students learned their traditional epistemologies through bush living.

The MPPP partnership also takes into account the idea that numeracy develops as and in social practices long before children go to school, and that contexts other than school are therefore significant in mathematics learning[18, 19]. This was also particularly relevant in the Distance Education case study, in which home-generated numeracy practices were often incorporated in children's learning, even if not formally acknowledged as a part of the Distance Education program. Importantly, however, parents in their early experiences of supervising distance education do not always appreciate the effect concrete materials can have in the support of productive learning environments and very little background information or rationale for tasks is provided. Consequently, the support they offer mirrors the type of teaching experiences they encountered at school. This is also seen in the Perth

Primary School example, in which the efficacy of the partnership is impacted by parents' prior experiences of 'drill and practice' mathematics education, and the potential for perpetuation of these understandings in their own children's numeracy practices. All too often negative experiences of mathematics and disengagement from the subject result.

We argue here that the effects of early numeracy practices are felt in later choices made by parents and students in relation to primary and high school study, university entrance and career choice. The implications of these results for later study and possible career choices in engineering, for example, are therefore significant. While 'educational choice' is often discussed in the literature as pertaining to choices between *types of school*[20], we have applied the notion of 'choice' in a broader sense – as those decisions made by parents and students about primary and high school study, the types of subjects taken, the modes of parent involvement and supervision of mathematical practices, and later choices in relation to university study and careers. This also moves the discussion beyond current application of 'sociocultural theory', which tends to emphasise classroom-centred learning and the construction of communities of practice in that specific context[21, 22, 23, 24, 25].

Much of the literature concerning tertiary study and engineering education emphasises the perceptions and understandings of late high school and undergraduate university students in relation to mathematics and science knowledges. Jacobs and Scanlon[26], for example, suggest that ongoing familiarity with engineering through primary and high school years is necessary for students to make choices appropriate to further study and careers in that domain, and recommend a 'marketing' strategy to encourage student interest and skills in the field[27, 28]. Recommendations such as those offered for undergraduate engineering students[29, 30], while significant in their increasing consideration of social contexts and other issues, often do not consider the diversity and history of individuals' numeracy practices, and the effects of these home- and community-generated understandings and experiences on approaches to mathematics education and educational choice. Dunn[31] states that it is "important that mathematics is seen as useful at school" and one way of achieving this is to "expose students to real data". This does not, however, address any potential lack of 'fit' between home, school and community expectations of mathematics education, its relevance and the modes of teaching and learning. The case studies detailed above point to the inadequacy of these approaches in understanding the full depth and breadth of factors which influence understandings of education and subsequent career choice.

There is, however, scant research evident in the literature describing or analysing this significant link between home and classroom experiences, and wider life circumstances and career choices. Research is needed into the effects of early development and its interaction with formal schooling practices which can shed light on the career choices made by individuals. Analysis of this link could include:

- Surveying current engineering students about their experiences of mathematics education;
- Describing students' family backgrounds, and the attitudes to mathematics with which they grew up; and
- Comparing engineering students with those in the humanities and social sciences, and their experiences of mathematics education.

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