TEACHER EDUCATION: A WATERSHED FOR PRESERVICE TEACHERS' ATTITUDES TOWARD MATHEMATICS

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This paper reports on the first and second phases of a longitudinal investigation of the attitudes of preservice primary teachers towards mathematics . An Attitudes to Mathematics questionnaire was used to construct profiles for each participant in three attitudinal domains - mathematics self-concept, attitude toward teaching mathematics and attitude toward teaching with the aid of technology . The profiles allowed monitoring of change in each of these domains as students progressed through their professional teacher education programs. Initial findings indicate that teacher education programs can provide a "watershed" for beginning teachers' to scrutinize and, where necessary, modify existing attitudes toward mathematics and the teaching of mathematics in primary schools.

There has been growing evidence to suggest that primary teachers often hold negative attitudes toward mathematics (Sullivan, 1987) and that this negativity may be reflected in the poor teaching of this curriculum area (DEET, 1989). Coupled with this, is the finding that an alarming proportion of preservice primary teachers lack the content knowledge to teach effectively mathematics (DEET, 1989). The recent initiatives by the NSW Department of School Education to increase the level of study of mathematics as a criterion for entrance to primary school teacher education programs reflects findings which link attitudes, achievement and level of study (Aiken, 1976; Kulm, 1980; Relich & Way, 1992).

Such findings and policy decisions have critical implications for the role of teacher education programs. Preservice primary teachers need to be encouraged to critically analyse and, if appropriate, revise their attitudes toward the teaching of mathematics and develop a positive perception of their abilities to teach it. It is the authors' beliefs that a major role of any mathematics education course should be to foster this process.

This report provides a summary of the first and second phases of a longitudinal investigation of the changing attitudes of preservice primary teachers at the University of Sydney towards mathematics. The project assumes that teacher education programs can have more than a superficial and short-lived impact on the attitudes of beginning teachers (Lortie, 1975; Martinez, 1992). Instead, it suggests that preservice programs have the potential to interact with personal past experiences and perspectives and to provide beginning teachers with the capacity and confidence to change not only their existing attitudes toward mathematics, but their attitude toward mathematics teaching practices - thus providing a "watershed" for change (Martinez, 1992). Knowing more about what attitudes propective teachers bring and how attitudes are modified by the different professional education components contributes to the overall impact of mathematics teacher education, and ultimately, mathematics education at the primary school level.

Background

Attitude toward mathematics of preservice primary teachers is of particular importance due to the potential these people have to influence the developing attitudes and self-concepts of young children (Aiken, 1976; Sullivan, 1987). The development of a positive attitude is desirable because of its association with achievement. Studies have found a low but significant correlation between attitude and achievement (Aiken, 1976; Kulm, 1980).

Recent investigations of preservice teachers' attitudes toward mathematics has started to reveal some interesting connections between mathematics attitudes, decisions to do further study in the subject, self-concept and attitudes toward the teaching of mathematics (Relich & Way, 1992; Way & Relich, 1993). While investigations have explored various components of attitude such as enjoyment, self-concept and anxiety, research by Marsh et al. (1985) and Relich and Way (1992), indicates that self-concept is a better measure of how people feel about themselves as teachers of mathematics, and that self-concept has an influence on the formation of attitudes. The findings suggest that teachers with low mathematics self-concepts may undermine the potential of students to learn, appreciate and react positively to math concepts (Relich, 1992). In addition, it seems that students with low self-concepts in mathematics are less likely to study mathematics at higher levels of education. Hence, many primary school teachers may not only possess negative attitudes toward mathematics, but may have chosen not to study the subject in their last years of high school (Aiken, 1976; Relich et al., 1991; Sullivan, 1987). Recent initiatives by the NSW Department of School Education to increase the level of study for mathematics as a criterion for entrance to primary teacher education programs reflects the research findings that link attitudes and self-concept to level of study, and to achievement in mathematics. While this initiative is consistent with research findings that link level of study to achievement, it does not take into account the underlying factors that predispose students to do more mathematics in the first instance. Furthermore, the existence of a link between attitude and achievement does not necessarily mean that improvements in one will automatically lead to improvements in the other - "neither attitude nor achievement is dependent on the other; rather, they interact with each other in complex ways" (McLeod, 1992).

An additional factor which needs to be investigated and, as yet, has received little attention by researchers, is the impact of calculators and computers. Technological changes in the curriculum will invariably be accompanied by changes in attitudes toward mathematics and toward the teaching of these subjects. This is particularly a concern for the education of preservice teachers given the high proportion of females who elect to teach at the primary school level and the research evidence which confirms that girls have poorer attitudes toward technology and lack confidence in its application, particularly in regard to computers (Ward, 1986).

The aim of the present study is to investigate the attitudes of two groups of preservice primary school teachers toward mathematics and toward the teaching of mathematics as they begin their teacher education. The project also aims to monitor these attitudes as the students progress through their respective teacher education programs (with a view to improve the programs if appropriate) and to follow these students into the first few years of their teaching careers. While the original investigation encompassed attitude toward both mathematics, science and technology, this paper focuses on findings related only to mathematics and technology.

THE STUDY

Participants

All students enrolled in the Diploma of Education (DipEd) program and the first year of the Bachelor of Education (BEd) program at the University of Sydney were invited to participate in the study. There was an 83% response rate from the BEd students and a 100% response rate from the DipEd students. A total of 138 students (92% female) agreed to take part in the first stage of the study with ages ranging from 17 years to 44 years.

Materials

The questionnaire was a modification of Relich and Way's (1992) instrument designed to assess attitude toward mathematics and was reformulated to incorporate attitude toward teaching mathematics with the aid of technology (namely, calculators and computers). The final version was a 24 item, Likert-type instrument comprising 3 scales: an attitude to teaching mathematics (ATM) scale (11 items), a mathematics self-concept (MSC) scale (9 items), and an attitude to teaching mathematics with technology (ATMT) scale (4 items). Each student received 3 scores - one for each of the attitudinal dimensions of the questionnaire. These scores were the algebraic sum of the individual items in each of the dimensions. Higher scores represent more positive attitudes.

Secondly, students were asked to complete a general information survey comprising 14 questions pertaining to background characteristics such as age, gender, reasons for commencing their course, and level of study for mathematics and science at high school and university. Due to length restrictions, a third component of the study, which involved interviews, will not be reported in this paper.

Procedure

Stage one : The questionnaire and general background information survey were administered to DipEd and BEd students prior to the commencement of their respective professional teacher education course components. Self-concept and attitude profiles were compiled from the questionnaire data for each participant.

Stage two: The questionnaire was readministered to DipEd students at the end of the same year, shortly before their teacher education was due to end. BEd students were not included in this phase of the study because they had not yet started the teacher education component of their course and it was considered unlikely that their attitudes toward the teaching of mathematics at the primary school level would have changed sufficiently to warrant investigation. The BEd students will complete round two of the questionnaire during semester two of 1994 after completing their first mathematics course unit.

RESULTS

General Information

The general information component of the questionnaire enabled the researchers to gain some insight into the background of the participants and to determine what developmental experiences are associated with differences in attitude toward mathematics. It is of interest to compare DipEd and BEd responses pertaining to level of study and factors influencing the level of study choice in high school for mathematics. Only 4.8% of BEd and 12.7% of DipEd students did no mathematics for their HSC, the majority of those who did study mathematics however (72.2% and 56.4% respectively), did so at lower levels (2 unit, 2 unit A or lower). Concerning reasons for choosing this level, BEd responses were fairly evenly distributed across four factors - personal enjoyment (19.3%), career prospects (18.1%), ability (18.1%) and tertiary education requirements (16.9%), but DipEd students chose personal enjoyment less often (12.7%) in favour of tertiary education requirements (25.5%) suggesting that students chose to study mathematics whether they enjoyed it or not.

At the tertiary level, only 16.9% of BEd and 56.4% of DipEd students undertook some mathematics. The declining number of prospective primary school teachers undertaking mathematics at this level is exacerbated by DipEd (Primary) program prerequisites. As one student voluntarily remarked in the open-ended response section of the questionnaire, "students with science degrees are excluded from the DipEd program unless they have taken some social science subjects as part of their undergraduate degree, but Bachelor of Arts students entering the DipEd program are not required to have any mathematics or science" as prerequisites.

Attitude Questionnaire

Questionnaire data were factor analysed using Principal Axis Analysis and varimax rotation. The analysis confirmed Relich and Way's (1992) identification of two attitudinal dimensions - attitude toward teaching mathematics (ATM) and mathematics self-concept (MSC) - and revealed that a third related, yet distinctly separate, dimension was created by the inclusion of the four items

pertaining to calculators and computers with factor loadings ranging between .68 and .84. This factor was referred to as the attitude toward teaching mathematics with technology (ATMT).

The scores on each of the subscales for mathematics were correlated with each other and the set of independent variables which described the general background of participants. The correlation indicated that there were some significant relationships among the three attitudinal dimensions and certain background variables. In particular, attitude toward mathematics and mathematics self-concept were significantly correlated ($r = .68$, $p < .001$). A significant negative correlation was found between attitude toward teaching mathematics with technology and gender ($r = -.25$, $p < .001$) indicating that females are more likely to display negative attitudes to teaching mathematics when calculators and computers are involved. These results confirm Way and Relich's (1993) findings that attitude and self-concept are related and further suggests that attitude toward teaching with technology may also be related. Clearly, attitude toward technology should be included in future investigations of preservice teachers' attitudes toward mathematics.

Regression analysis was used to determine what background characteristics were the best predictors for each of the subscales on the questionnaire. The analysis revealed that attitude to teaching mathematics is clearly predictable from independent variables such as age, what students were doing prior to commencing their teacher education training, the level of science studied in year 10 and at the tertiary level, and the level of mathematics studied in years 11, 12 and at the tertiary level (multiple $R = .44$, $p<.0001$). However, mathematics self-concept was not clearly predictable from any of the variables investigated. Hence, while correlation data indicates a strong relationship between mathematics self-concept and attitude toward teaching mathematics, regression analysis indicates that, unlike attitude, self-concept is not easily predictable from the background characteristics of individuals. This not only confirms Way and Relich's (1993) findings, but contributes to the 'mystique' surrounding the development of positive mathematics self-concepts.

Mean scores and standard deviations for each subscale of the attitude to mathematics questionnaire were calculated for the total sample and for each subgroup of the sample (see Table 1). Two tailed t-tests were used to determine if there were significant differences between the mean scores of students from the two teacher education programs for each subscale. There were no significant differences between the means of the two groups for ATM ($t = .91$, $p>.05$), MSC ($t = .94$, $p>.05$), or ATMT ($t = 1.69$, $p>.05$) indicating that there were no differences between the DipEd and BEd students on any of the mathematics attitude subscales.

While frequency distributions revealed normal distributions when mathematics self-concept scores were calculated for the sample as a whole, a different picture was revealed when scores were calculated separately for the two subgroups. There were 2 students (or 3.7%) from the DipEd program that obtained extremely positive scores on the mathematics self-concept scale

(a normal distribution would expect to contain only 2.2 %), but there were no students from the BEd program that fell into the same extreme category.

The questionnaire was readministered to the DipEd students at the end of the year, shortly before their teacher education courses were due to end. A total of 46 students (or 90% of those who completed the program) responded to the questionnaire for the second time. Table 1 presents the DipEd mean scores and standard deviations for round 1 and 2 of the questionnaire.

Table 1 Mean scores and standard deviations for each subscale of the instrument for round 1 and 2 of the questionnaire.

Factor		BEd Round 1 n = 83	DipEd Round 1 n = 55	DipEd Round 2 n = 46
Attitude to teaching (Max = 55)	mean	31.8	33.1	38.5
	SD	8.1	8.7	8.1
Self-Concept (Max = 45)	mean	30.8	29.5	31.1
	SD	7.8	8.1	9.5
Attitude to teaching with technology (Max = 20)	mean	12.3	13.6	15.0
	SD	4.7	4.4	3.1

It is clear from Table 1 that scores for each subscale obtained at the end of the DipEd program improved for each of the domains, with the greatest improvement occurring for the attitude toward teaching mathematics domain. Two tailed t-tests were used to determine if there were significant differences between the mean scores for each subscale. There was a significant difference between the means for ATM ($t = 3.9$, $p < 0.05$), but no significant difference for MSC means ($t = 1.9$, $p > 0.05$). These findings were supported by comments volunteered by students at the end of the questionnaire. For example:

> "(The) way the courses of science and maths have been conducted have given me confidence to teach; even though I am not naturally good at science or maths."
>
> "I'm not so much afraid of teaching maths and science but more concerned that I myself missed the whole point - particularly of maths when I was at school."

Student responses of this nature support the commonly held belief that mathematics achievement is more a question of inherent ability and that any lack of ability is considered a permanent feature over which they have little control. These results support Way and Relich's (1993) suggestion that self-concept is much more resilient to change than attitude and highlights how critical it is to foster positive self-concepts from a very young age.

While mean scores indicated a significant improvement for ATMT ($t = 2.2$, $p < 0.05$), further analysis was conducted when voluntary comments at the end of the questionnaire indicated that the attitudes of many students toward calculators and computers differed significantly. Results indicated that students had more positive attitudes toward teaching with calculators than they did with computers ($t = 8.0$, $p < 0.0001$). Students commented that they thought the courses undertaken as part of their teacher education had not adequately prepared them to teach mathematics with computers and many expressed concerns about the adequacy of their own computer knowledge.

> "It worries me that with the way technology is advancing I may not be able to keep up with the changes i.e. the children will possibly know more about computers than I will?!"

DISCUSSION AND CONCLUSIONS

While the second stage of the study has involved only the DipEd students to date, some conclusions may still be drawn. It seems that mathematics teacher education programs can provide beginning teachers with a "watershed" to allow adequate scrutiny and revision of their attitudes toward mathematics and toward the teaching of mathematics. This is evidenced by the significant improvement on the attitude toward teaching mathematics component of the questionnaire. While it is clear from the findings of this study that attitude toward mathematics is a result of experiences at high school and that quality teacher education courses can be influencial in effecting some revision of attitudes, mathematics self-concept remains more difficult to predict and more resilient to change.

Furthermore, an important issue raised by this study is the impact of technology on attitude. The fact that DipEd students continued to display poor attitudes toward the teaching of mathematics with the aid of computers and expressed concerns about their own level of computer knowledge could be a function of their gender and/or the age of many students: more than 36% of DipEd students would have had little or no contact with computers at school. In addition, qualitative comments volunteered by participants indicated that many considered the computer component of the mathematics education course inadequate preparation given their level of background knowledge. As noted by Martinez (1992), where teacher education provides competent preparation beginnging teachers are equipped to adhere confidently to practices expounded in their teacher education courses, but where inadequate preparation has been provided, beginning teachers are more likely to revert to more traditional practices or comply with pre-existing contextual conditions. Hence, while not solely a function of teacher education course quality, initial training can have a significant influence on the ability of novice teachers to attempt innovation in the face of existing school practices.

The fact that BEd students undertake their professional education courses over a longer period of time (three years), rather than one year as for DipEd, may have implications for greater changes in self-concept and may provide a better opportunity to address issues related to technology. In this sense, it will be of more interest to compare DipEd results with BEd data when they reach the end of their teacher education program.

REFERENCES

Aiken, L. (1976). Update on attitudes and other affective variables in learning mathematics. *Review of Educational Research*, 46, 293-311.

DEET (1989). *Discipline Review of Teacher Education in Mathematics and Science*. Department of Education, Youth and Employment.

Kulm, G. (1980). Research on mathematics attitude. In R. Shumway (Ed.), *Research in Mathematics Education* (pp. 356-387). Reston: NCTM.

Lortie, D. (1975). *Schoolteaher: A sociological study*, Chicago: University of Chicago Press.

Marsh, H. (1988). Self-description questionnaire: A theoretical and empirical basis for the measurement of multiple dimensions of pre-adolescent self-concept: A test manual and research monograph. The Psychological Corporation, San Antonio, Texas.

Marsh, H., Cairns, L., Relich, J., Barnes, J., & Debus, R. (1985). Multidimensional self-concept: Relations with sex and academic achievement. *Journal of Educational Psychology*, 77, 581-596.

Martinez, K. (1992). Teacher education: Wasteland or watershed? *A.E.R.* 19, 1, 1992.

McLeod, D. (1992) Research on affect in mathematics Education: A reconceptualisation. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*, MacMillan.

Relich, J. (1992). Self-concept profiles and teachers of mathematics: implications for teachers as role models. *Proceedings of the sixteenth PME conference*, Durham: PME.

Relich, J., & Way, J. (1992). Preservice primary teachers' attitudes to teaching mathematics: A reappraisal of a recently developed instrument. In B. Southwell, K. Owens & B. Perry, *Proceedings of conference for MERGA*, University of Western Sydney, Nepean: MERGA.

Sullivan, P. (1987). The impact of a preservice mathematics education on beginning primary teachers. *Research in Mathematics Education in Australia*, August, 1-9.

Ward, R. (1986). Girls and technology. In L. Burton, (Ed.). *Girls into maths can go*. Holt, Rinehart and Winston.

Way, J., & Relich, J. (1993). *Proceedings of conference for MERGA*, Brisbane: MERGA.