DEVELOPMENT OF POSITIVE ATTITUDES TO MATHEMATICS: THE PERSPECTIVE OF PRE-SERVICE TEACHERS

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This paper reports on the further development of an instrument designed to measure self-concept in mathematics and the attitude of pre-service teachers toward the teaching of mathematics. It presents the results of the questionnaire's application to teacher education students across various programs at the University of Western Sydney, Nepean. The findings of the study revealed that the students' attitude towards teaching mathematics improved as they progressed through the programs, but that their self-concept in mathematics remained unchanged by the experience. In addition there were clear and significant differences in attitude to teaching mathematics and self-concept in mathematics based on gender and program of study. Males compared to females were found to display consistently higher levels of self-concept and more positive attitudes. Secondary students also displayed significantly higher scores on both constructs than did primary students who in turn scored consistently higher than early childhood students.

Attitudes and Pre-service Teachers

"An important aim of mathematics education is to develop in students positive attitudes towards mathematics and their involvement in it.....The notion of having a positive attitude towards mathematics encompasses both liking mathematics and feeling good about one's own capacity to deal with situations in which mathematics is involved." (Australian Education Council, 1991, p.31)

This extract from A National Statement on Mathematics for Australian Schools reflects the widespread belief among educators in the importance of the development of positive attitudes in the teaching and learning of mathematics.

Although definitions of attitude vary, they generally include the ideas that attitudes are learnt, manifest themselves in one's response to the object or situation concerned, and can be evaluated as being either positive or negative (Leder, 1992). One such definition states...." Attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related " (Allport in Kulm, 1980, p.356). When exploring the attitudes of pre-service teachers toward mathematics it is necessary to not only to consider their attitude towards the subject itself, but also their attitude regarding the teaching of mathematics.

The attitudes of pre-service teachers are of particular importance because of their potential influence on pupils. Although the research evidence is certainly not conclusive it has been sufficient to suggest that positive teacher attitudes contribute to the formation of positive pupil attitudes (Aiken, 1976; Sullivan, 1987). There is an additional concern that female teachers, who constitute the majority of primary school teachers, may be perpetuating negative attitudes with the girls in their classes (Kelly & Tomhave, 1985; Relich, Conroy, & Webber, 1991). Some studies have indicated that teacher attitudes towards a subject and the teaching of that subject influence the instructional techniques they employ and that these, in turn, may have an effect on pupil attitudes (Carpenter & Lubinski, 1990).

One argument presented in support of the need for positive attitudes is that such attitudes can enhance achievement in mathematics at primary, secondary and tertiary level (Dungan & Thurlow, 1989). Most studies on the relationship between attitude and achievement have revealed a low but significant correlation (Aiken, 1976; Kulm, 1980). However, the nature and direction of this relationship is yet to be unravelled (Kulm, 1980; Suydam, 1984).

Unfortunately large proportions of pre-service teachers have been found to hold negative attitudes towards mathematics and mathematics teaching (Becker, 1986; Sullivan, 1987). Some studies have revealed links between attitude to mathematics, the choice or avoidance of mathematical studies, self concept and attitudes

towards the teaching of mathematics. It appears that students (both male and female) with low self-concepts in mathematics are less likely to pursue mathematical studies. Not surprisingly then, research has shown that most pre-service teachers who exhibit negative attitude towards mathematics have not chosen to study mathematics in their final years of high school (Aiken, 1976; Relich, Conroy, & Webber, 1991; Sullivan, 1987).

The potential of teacher training courses to change the negative attitudes of pre-service teachers towards mathematics must also be considered. Sullivan (1987) found that almost half of the students entering a teacher training course possessed negative attitudes towards mathematics. He states..."The course improved their attitudes overall, but those who started with negative attitudes still had the most negative attitudes at the end." (Sullivan, 1987, p.1). He concluded that if these initial attitudes are so significant, teacher education courses may need to establish entry criteria based on the mathematics background of the applicants.

Several studies suggest that beginning teachers are especially concerned about methodology as well as content and therefore training courses should cater for this (Aiken, 1976; Blunden & De La Rue, 1990; Mansfield, 1981; Sovchik et al., 1981; Watson, 1987). Relatively high correlations have been found between mathematical achievement, the enjoyment of mathematics and the perception of mathematics being useful, which also carries implications for the design of teacher education courses (Watson, 1987). If the attitudes of pre-service teachers are to be improved, there first needs to be a reliable instrument with which to measure levels of attitudes and perhaps to identify groups of students with special needs (Aiken, 1976; Nisbet, 1991; Watson, 1987).

Measuring Attitudes

In recent years, researchers of 'attitude' have acknowledged that attitude appears to be a multi dimensional construct and therefore requires a multi dimensional measure (Leder, 1992). However, there is some dispute as to which components of attitude, such as anxiety, enjoyment, self-concept and belief in the usefulness or value of mathematics, provide the best indicators of attitude.

One component that has received much attention is that of 'mathematics anxiety'. There is little doubt as to the existence of 'mathematics anxiety' and a number of instruments for measuring levels of anxiety have been developed and implemented (Richard & Suinn, 1972). However, Sovchik, Meconi and Steiner (1981) suggest that the construct 'mathematics anxiety' is not as well defined and measurable as assumed by some mathematics researchers. There is some doubt as to whether anxiety is in fact a separate construct. It may just be a reflection of some deeper attitude (Wood, 1988). For example, Bandura (1982) points out a person may judge that a particular action will result in a particular outcome (expectancy judgement), but may doubt his/her ability to successfully perform the action (efficacy judgement), which in turn may be related to existing anxiety or the production of anxiety. Anxiety's relationships to factors such as enjoyment, general attitude towards mathematics and performance are unclear. Wigfield and Meece (1988) concluded that mathematics anxiety and perception of mathematics ability are conceptually distinct, though related, constructs. Others argue that self-concept is a better measure of how people feel about themselves as mathematicians and as teachers of mathematics, and that self-concept has an influence on the formation of attitudes (Relich, Conroy, & Webber, 1991; Relich & Way, 1992). Studies have also found a consistently high positive relationship between self-concept and mathematics achievement (Hackett & Benz, 1989).

Instruments designed for determining the attitudes of pre-service teachers towards mathematics and the teaching of mathematics have been scarce. Nisbet's (1991) instrument consisted of the Fennema and Sherman (1976) 'Mathematics Attitude Scales' plus his own parallel scales constructed to cover the 'Attitudes to Teaching Mathematics' aspect. Neither of these scales included items regarding self-concept. Relich and Way (1992) supplemented Nisbet's instrument with self-concept items developed by Marsh (1988) to form a large composite questionnaire, referred to as the "Teaching Mathematics Questionnaire". The results of this study (Relich & Way, 1992) supported the contention that attitude towards mathematics and the teaching of mathematics can best be defined through feelings about the teaching of mathematics and through self-concept of one's abilities to cope with mathematical tasks. Anxiety did not emerge as a separate variable, but was highly correlated with attitude and therefore subsumed into the attitudinal profiles.

The major purpose of this research was to further validate the relevance of this questionnaire in accurately gauging attitude towards mathematics among pre-service teachers, and to determine how attitude differs based on characteristics such as program of study, year of study, level of previous study of mathematics in high school and tertiary institutions, age and gender. The questionnaire focuses on "attitude to teaching mathematics" as measured by a composite scale (see Relich & Way, 1992) and "self-concept in mathematics". Through a cross-sectional analysis of student data at various levels of study, we can determine whether attitude and self-concept change as pre-service teachers progress through their course and whether changes in attitude are concomitant with changes in self-concept.

METHOD

Subjects

The questionnaire "Teaching Mathematics" developed by Relich and Way (1992) was used to gather information from all students in Education at a NSW university. A total of 564 students participated across a variety of programs with a substantial majority (85%) being female. The subjects represented all the years of study within the programs and were asked to participate on a voluntary basis in completing the forms. They represent approximately 70.5% of the population of students within the Faculty enrolled in these programs. Over 81% studied mathematics in high school at the 2 unit level or less. Those who undertook study at the three or four unit level were represented in all the programs but constituted the majority (67%) of secondary students.

Instrumentation

The "Teaching Mathematics Questionnaire" consists of 20 items, 11 related to specific attitudes on the teaching of mathematics and nine mathematical self-concept items. The development of this instrument, an adaptation and amalgamation of various currently available instruments, is discussed in detail in Relich and Way (1992). The 20 items required Likert scale responses on an eight point continuum from definitely false to definitely true. For those statements which referred to practice teaching experiences, participants had an option of indicating that the question was not applicable. The purpose of this category was twofold. First to cater for students in their first year who may not have had such an experience and second to gauge what proportion of students may not view themselves as teachers of mathematics.

A test of reliability using Cronbach alpha suggests that the two sub-scales are highly reliable with coefficients of .92 for the attitude scale and .88 for the self-concept scale.

Procedure

The administration of the questionnaire took place during normal lecture periods when a majority of students within a particular year and program were all expected to attend at the same time. Students were briefly instructed about the purpose of the questionnaire and given information about how to complete it on a voluntary basis. They were however encouraged to participate because the researchers wish to conduct a longitudinal study. While no student can be directly identified in order to ensure anonymity, each student was able to provide an identification number known only to the participant. No more than ten to fifteen minutes of class time were required to complete the task.

Regression analysis was used to examine the results and to determine what set of independent variables were the best predictors of attitude to the teaching of mathematics and self-concept in mathematics. We also used t-tests and oneway analysis of variance to determine if there were significant differences in response patterns based on gender, program and year of study variables. These techniques were used in preference to factorial analysis of variance because the "not applicable to me" response reduced much of the available data from the early childhood and first year students across all programs resulting in either empty cells or cells with very small numbers.

RESULTS

An initial correlation analysis indicates that there are some significant relationships among attitude, self-concept and the set of independent variables. In particular attitude and self-concept are significantly ($r=.62$, $p<.001$) correlated and share over 36% variance. Attitude ($r=.12$, $p<.005$) and self-concept ($r=.10$, $p<.05$) are significantly related to gender, indicating that males are significantly more likely to display positive attitudes to teaching mathematics and register higher self-concept in mathematics than females. There is a similar positive and significant relationship between level of study of high school mathematics and attitude ($r=.15$, $p<.001$) and self-concept ($r=.32$, $p<.001$) suggesting that higher levels of study at this level are associated with more positive attitudes and higher self-concepts. Interestingly, it is significantly more likely that males study high school mathematics at a higher level than females ($r=.09$, $p<.05$). There is also an interesting relationship between age and the two dependent variables. While older students are significantly ($r=.15$, $p< .001$) more likely to have positive attitudes, younger students display significantly ($r=-.10$, $p<.05$) higher levels of self-concept. On an encouraging note, there is a positive and significant ($r=.35$, $p<.001$) relationship between the year of study and attitude, with those in the latter years of study exhibiting more positive attitudes. For self-concept, however, no such relationship exists suggesting little change on this construct as students progress through their programs of study.

Stepwise regression analysis was used to determine which set of independent variables were the best predictors of attitude and self-concept. Gender, level of study of high school mathematics and year of study all contributed significantly (multiple $R=.30$, $p<.001$) to the prediction of attitude to teaching mathematics. For self-concept, however, level of study of high school mathematics provided the most significant ($r=.34$, $p<.001$) relationship which was not significantly improved by the inclusion of any other variable.

Significant gender differences in attitude ($t=3.94$, $p<.001$) and self-concept ($t=3.68$, $p<.001$) were verified through the use of t-tests. In addition significantly ($p<.05$) more positive attitudes and higher self-concepts were found among secondary ($m=77.8$, $s.d.=8.5$; $m=43.5$, $s.d.=8.2$) students when compared to primary ($m=69.2$, $s.d.=13.0$; $m=36.7$, $s.d.=9.8$) students who in turn had significantly ($p<.05$) more positive attitudes than early childhood ($m=59.1$, $s.d.=10.3$; $m=33.4$, $s.d.=8.2$) students. A further oneway analysis based on the year of study confirmed the significant ($p<.05$) attitudinal changes from the second ($m=67.0$, $s.d.=13.9$) year of study to the third ($m=70.4$, $s.d.=11.3$) year of study. No similar changes occurred for self-concept profiles.

These results strongly suggest that while attitude to the teaching of mathematics may be ameliorated through participation in a teacher training programs which focus on the affective state of the student, self-concept seems far more resistant to change. Those who enrol in teacher training programs with high levels of study in mathematics at the high school level, generally tend to have more positive attitudes and better self-concepts. This type of student profile is also much more likely to be exhibited by the males compared to females.

DISCUSSION

The application of this questionnaire to such a large sample and the consequent findings further validates its relevance for teacher trainers in mathematics. It was clear from the results that attitude and self-concept while highly related are separate constructs. Although there were clear attitudinal changes towards the teaching of mathematics occurring in the latter years of study, it is clear that self-concept is stable and not easily malleable. The evidence suggests that pre-service teachers do change their attitudes about their ability to teach mathematics but unfortunately do not perceive themselves as better mathematicians as a consequence. This raises the question as to whether such changes are enduring and even whether such changes are superficial and inconsequential to their overall ability to deal effectively with mathematics lessons. Perhaps the other side of the argument is that as educators we should be grateful for any positive changes that we can engender and that expecting to change self-concept is not a realistic goal. Nevertheless, there is something inherently attractive to a teacher in attempting to change deeply entrenched views about personal ability and the possible consequent positive effect that this may have on the enthusiasm of a future teacher for mathematics.

All the evidence continues to point to differences in attitude and self-perceptions in mathematical ability between males and females. Our evidence is clear that these differences are the baggage that students bring with them from their study at the high school level. Those who studied mathematics at higher levels are more likely to be advantaged and invariably such students are more likely to be male than female. Given the high proportion of females to males, especially at the primary and early childhood levels, we need to continue to seek ways in which to encourage girls to attempt higher levels of study in mathematics. This of course assumes that the level of study has an effect on subsequent levels of self-concept but this is not entirely clear. It is also possible that those with greater self-concept seek out the more challenging mathematics subjects. Whatever the explanation may be, these are issues which we need to continue to study and address if we hope to deliver quality programs which will result in teachers at all levels who are positive not only about their ability teach mathematics but also about their own levels of skill and ability as mathematicians.

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