A NEW APPROACH TO MEASURING PRE-SERVICE TEACHERS' ATTITUDES TOWARDS MATHEMATICS

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Research (for example Ball, 1988; Philippou & Christou, 1998) have linked teachers' attitudes with classroom practice in teaching mathematics. Previous studies have identified and examined the relationships between different components of teachers' attitudes (Nisbet, 1991). However, a particular criticism of these studies is the lack of content validity of the measures used. In the present study, in line with the conference theme for PME 38, we developed an innovative approach to examining the attitudes of pre-service elementary teachers. The study utilised a mixed methods approach, firstly eliciting qualitative statements from teachers, then using these statements in Likert-scale questionnaire items. We argue that this provides a more valid assessment of attitudes, and a method that can be applied across differing contexts for teachers.

FOCUS OF THE STUDY

Research has highlighted the importance of teachers' attitudes to mathematics. Aiken (1970) stated that teachers' attitudes were particularly important for students' attitudes towards the subject. Ernest (1989) also emphasised the importance of teachers' attitudes as being important for student achievement. Elsewhere, Ball (1988), Philippou & Christou (1998) and Wilkins (2008) have linked teachers' attitudes with classroom practice in teaching mathematics. In the UK context, school inspection evidence shows that teachers' lack of subject knowledge and confidence in mathematics contributes to low standards of mathematics attainment of pupils (Rowland et al., 2000). Despite this importance, researchers have also stated that many pre-service teachers come into the profession with negative feelings towards the subject (Ball, 1988; Nisbet, 1991; Philippou & Christou, 1998). It is therefore important that we use valid measures of pre-service teachers' attitudes to identify any concerns. In this study, we developed an innovative approach to examining and measuring pre-service elementary teachers' attitudes towards mathematics which we describe in this report.

THEORETICAL FRAMEWORK

Oppenheim (1992) defined 'attitude' as a "state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli" (p.174). More specifically, there has been general agreement in the literature that attitudes consist of cognitive, affective and behavioural components (Bagozzi & Burnkrant, 1979; Ajzen, 2001; Crano & Prislin, 2006). According to McGuire (1969), the cognitive component "refers to how the attitude object is perceived, its conceptual connotations – it is the "stereotype the person has of the attitude object"" (p. 155). The affective component "measures the

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degree of emotional attraction towards an attitude object" (Bagozzi & Burnkrant, 1979, p. 915). There are then the "person's gross behavioural tendencies regarding the object" (McGuire, 1969, p. 156). We used this 'tripartite' view of attitude as the starting point for this study.

PRE-SERVICE TEACHERS' ATTITUDES TOWARDS MATHEMATICS

Studies have identified and examined the relationships between different components of teachers' attitudes' towards mathematics (Nisbet, 1991). Schofield (1981) measured two aspects of teacher attitude, namely attitude towards mathematics and attitude towards teaching mathematics. Likewise, Ernest (1989) highlighted these two aspects, identifying within attitude towards mathematics the components of teachers' liking, enjoyment, interest, self-concept and valuing of the subject. Others studies on teachers' attitudes have tried to measure these different components. Nisbet (1991) developed attitude measures to teaching mathematics, consisting of the four separate dimensions of anxiety, confidence and enjoyment, desire for recognition, and pressure to conform in teaching mathematics. Relich, Way and Martin (1994) criticised Nisbet's instruments, and emphasised the inclusion of teachers' self-concept in the subject, alongside anxiety, enjoyment, and belief in the usefulness or value of mathematics. Similarly, Wilkins (2008) used a measure looking at enjoyment, importance and the teaching of the subject, as well as feelings of success within mathematics. Ludlow and Bell (1996) developed an instrument based on existing items on self-concept, teaching of maths and doing or performing mathematics. Finally, more recently, Evans (2011) used an existing questionnaire developed by Tapia (1996, cited in Evans, 2011, p.228) including confidence, value, enjoyment and motivation. It is seen that there are components that frequently occur, such as enjoyment, self-concept, confidence, usefulness and teaching of mathematics.

The above studies used measures of attitudes, mostly based on Likert-scale responses to items related to particular components of attitude, to achieve reliable instruments required for larger scale studies of attitudes of pre-service teachers. However, a criticism that can be levelled at all these studies is the lack of content validity of the measures used. The question raised by Oppenheim (1992) is whether "the items or questions are a well-balanced sample of the content domain to be measures" (p.162). Although there is generally good theoretical agreement regarding the important components of pre-service teachers' attitudes, these are still theoretical assumptions, and the differences between the above studies illustrate the possible problems involved in identifying the 'valid' components. A solution to the problem of construct validity is to derive attitude questionnaire items from students' responses to more open-ended items (Oppenheim, 1992). Therefore, the present study adopted an innovative approach to identifying different components to pre-service teachers' attitudes to mathematics, incorporating both free responses to open-ended items and Likert-scale measures of attitudes.

METHODOLOGY

Methodology and methods

Leading on from the literature, the aim of the study was to develop an approach to identifying components of attitudes for a particular group of pre-service elementary teachers, and in turn develop valid, reliable measures for these components, and to then examine the relationships between these components (in line with Nisbet, 1991). The specific research questions to be answered were:

- Using both qualitative and quantitative approaches, what different components of attitudes towards mathematics emerge from the analyses for a particular group of pre-service elementary teachers?
- Using the resulting quantitative measures of attitudes, what relationships exist between measures of these components of attitude?

In balancing the requirements of identifying both the valid components of attitudes with the requirements of developing reliable measures, a *critical realist* methodological perspective was taken. This perspective balanced the positivist approach of measuring attitudes whilst "taking note of the perspectives of participants" (Robson, 2002, p. 30). Within this perspective, the study used a mixed methods approach, "combining qualitative and quantitative approaches within different phases of the research process" (Tashakkori & Teddlie, 1998, p. 19). In the first phase of the study, a questionnaire was given to pre-service elementary teachers which asked them to give a short written response to three statements: (a) What I perceive/think of with maths; (b) How I feel about maths; and (c) How I behave towards maths. The statements were designed to elicit open responses regarding teachers' cognitive, affective and behavioural components of attitude and no other guidance was given. The resulting statements were then analysed and coded to categorise the statements. In doing so, the analysis was guided by Tesch's (1990) (cited in Creswell, 1994, pp. 154-155) systematic steps to analysing qualitative data. At this stage, the statements from the three areas of attitudes were coded separately. In the second stage of the study, from the twelve most frequently occurring categories, six statements from each category were randomly chosen (if repetition of content occurred within statements, the second statement was discarded and another statement randomly chosen). The resulting statements were then used in a 72-item Likert-scale attitude questionnaire, with the items randomly ordered. Slight modifications of wording within statements were made for clarification if deemed necessary. A response from five possible options to each item was asked for: strongly agree; agree; neither agree nor disagree; disagree; strongly disagree. Having compiled the questionnaire, the pre-service teachers were asked to complete this. The obtained results were coded (5 = 'strongly agree to 1 = 'strongly disagree'), with negative items reverse coded. These quantitative results were analysed in SPSS using exploratory factor analysis to confirm the dimensions of attitude, and reliability analyses were carried out on the resulting groups of items to

confirm the quality of the measures. Linear regression analysis was also subsequently carried on the resulting measures of attitude.

Sample

The sample of pre-service teachers involved in this study was comprised of students studying on a one-year Postgraduate Certificate in Education (PGCE) course at Durham University in the UK. The course qualifies students to become elementary teachers. All these pre-service teachers had already obtained an undergraduate degree, although different teachers had studied very different disciplines. In terms of their mathematical qualifications, these ranged from teachers with a minimum of GCSE qualifications in mathematics from examinations at the end of compulsory education in the UK, to teachers with top grades in Advanced-level mathematics from examinations prior to commencing university studies. In the first phase of the study, 78 students completed the open-responses questionnaire. For the second phase of the study, 90 students completed the Likert-scale questionnaire. This difference in numbers was due to the initial questionnaire being given at a pre-course training day to which some students were unable to attend.

RESULTS

Qualitative results

Beginning with the qualitative statements obtained from the pre-service teachers, the statements were categorised into the following groups (Table 1). From the cognitive, affective and behaviour statements, the pre-service teachers could view mathematics positively (i.e. enjoyable, important, confidently, committed) or negatively (difficult, avoiding). Clearly, there were some overlaps between the categories identified for different types of statements, but for the purposes of further analysis, these categories were kept separate for the next stage of the study.

From cognitive statements	From affective statements	From behaviour statements
Maths as difficult (42%)*	Enjoyable/fun (35%)*	Behave positively (36%)*
Maths as important (29%)*	Challenging (29%)*	Committed to maths (35%)*
Maths as enjoyable (27%)*	Confidence or self-concept (28%)*	Behave negatively (29%)*
Involving number (14%)	Very negative (24%)*	Specifically avoid (27%)*
As problem solving (12%)	Useful (15%)	Doing maths (19%)*
As right or wrong (10%)	Prepared to work on (10%)	Do mental maths (9%)
Other (9%)	Teaching of maths (6%)	Other (4%)
	Other (4%)	

Table 1: Categories of statements emerging from the analysis of qualitative statements

Quantitative results

Based on the above categories, the twelve most commonly identified categories (indicated with * in Table 1) were used to compile the Likert-scale attitude questionnaire. The choice of twelve categories were based on gaining a balance between covering as many categories as possible, but not having too many so that the questionnaire became unwieldy. Twelve categories with six items for each category resulted in a 72-item questionnaire which was viewed as reasonable in terms of length. Four subsequent dimensions were identified in the factor analysis, with items grouped as positive attitudes, negative attitudes, commitment to maths and usefulness/importance of the subject (these dimensions tended to be mixed in terms of items related to cognitive, affective and behavioral components). Subsequently, reliability analysis was also carried out on each of these group of items identified, and the Cronbach α values calculated (Table 2). Very high values of Cronbach α were obtained for three of the dimensions, with all the measures having reliability values greater than the benchmark of 0.7.

Dimension identified	Number of items	Exemplar items	Cronbach α of resulting measure
Negative attitude	23	I feel a lack of confidence in maths; I am nervous and anxious about maths	0.97
Positive attitude	16	I am positive towards and about maths; I like maths	0.96
Commitment to maths	9	I try hard in maths; I am keen and willing to learn maths	0.85
Usefulness/importance of maths	6	Maths is a very useful tool; Maths is useful in everyday function.	0.76

Table 2: Dimensions of attitudes emerging from the quantitative data

The above quantitative analysis therefore refined the dimensions of attitude identified in the qualitative stage of the study, and in turn led to the development of reliable and valid quantitative measures for these dimensions. These measures could then be used further to examining the relationships between the different dimensions of attitudes. For example, linear regression analysis was used to find out which other dimensions were significant predictors of larger values on the positive attitude measure, this being deemed to be a desired outcome for pre-service teachers. We found that the negative attitude measure and the commitment measure were both found to be significant correlated to the positive attitude measure. Plotting the position of each of the pre-service teachers on the positive and negative measures of attitude (Figure 1), we found unsurprisingly that there was a strong relationship; however, we also found a triangular relationship which showed that having a high score on the negative attitude measure (and since negative items were reversed, this means not agreeing with

negative statements) was a sufficient, but not necessary condition for a high score on the positive attitude measure.

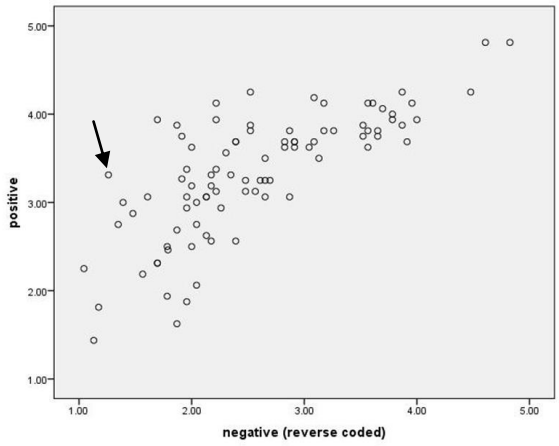

Figure 1: Plot of the positive and negative attitude measures

In fact, from the linear regression results, they showed that a commitment to mathematics also contributed to a positive attitude to the subject. We further illustrate this qualitatively by choosing one of the pre-service teachers who had quite a high score on the positive attitude measure, despite scoring very low on the negative attitude measure (shown in Figure 1 with the arrow). Her qualitative statements included: "A subject that does not come naturally to me. When I was at school I was not inspired by maths ... With maths I feel the least confident out of the core subjects ... Since deciding I wanted to be a teacher I have a very positive attitude towards learning maths. I am/will do everything I can to improve my subject knowledge." What we highlight here is that due to the approach to identifying and measuring dimensions of attitudes where the dimensions emerge from the analysis, we did not exclude important dimensions such as the commitment to mathematics which in turn were related to other important, desirable dimensions of attitude.

DISCUSSION

The methodological approach taken in the study identified a number of components of attitude held by the pre-service elementary teachers involved. An advantage of looking first at the qualitative statements from teachers was that we could identify straightforwardly which were the more significant components of attitude (Table 1). Choosing the twelve most frequently occurring categories identified through the analysis, these significant components involved difficulty of mathematics, importance, enjoyment, challenge, confidence or self-concept, positive and negative views, commitment to the subject and attitude towards doing or avoiding mathematics. There is a great deal of agreement between these identified categories and the literature, for example with Ernest's (1989) components of teachers' liking, enjoyment, interest, self-concept and valuing of the subject. Having identified these categories qualitatively, an added advantage of the current approach was that quantitatively and statistically, through exploratory factor analysis, we could further validate these

categories. In fact, from the exploratory factor analysis (Table 2), the analysis refined these dimensions to more general positive and negative components of attitudes towards mathematics, as well as the importance of the subject and a commitment to mathematics. Relating these components to those identified in previous studies, the component which we termed commitment relates to the component of 'motivation' examined by Evans (2011).

Having obtained valid, reliable measures of attitudes of the pre-service teachers, in examining the potential relationships between the different components, although there was an unsurprising inverse relationship between positive and negative attitudes to mathematics, the triangular distribution in Figure 1 emphasised the importance of the commitment component of attitude. Indeed, an extension to this study will be to identify pre-service teachers who score highly on this commitment measure, and to examine further what factors support this commitment, particularly for teachers who may additionally have quite negative attitudes to mathematics.

One component of attitude that did not emerge from the current study, in disagreement to the previous research, was pre-service teachers' attitude towards teaching mathematics. A possible explanation for this is that the teachers in the study were at the very beginning of their training, and therefore had not yet been in schools to teach mathematics as part of their course. Therefore, teaching the subject may not have been a significant component of attitude for the teachers at that particular stage of their careers. In fact, this issue highlights a further advantage of the method used to examine attitudes of teachers. Because of the focus on content validity (Oppenheim, 1992) and the use of qualitative statements to draw out the relevant components of attitude, the particular context of the teachers was taken into account. This means that this approach to examining attitudes can be transferred between quite different contexts, for example teachers at different stages of their careers or in different countries, without assuming the same components of attitude. In addition, the flexibility of the approach allows for an examination of specific aspects of attitude. For example, the study could be extended to specifically examine pre-service teachers' attitudes to teaching mathematics by changing the focus of the initial open statements. Or, we could focus on areas within the subject such as attitudes towards mental calculations or attitudes towards problem solving, two aspects that emerged to a degree from the qualitative statements of teachers. We therefore propose that the approach used in this study can be a powerful method for examining teachers' attitudes towards mathematics (or indeed for other groups or for other topics).

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