Do You Like Maths?

Development of a Questionnaire for Assessing Primary School Students' Attitudes towards Mathematics

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ABSTRACT

The importance of student attitudes towards school subjects for their learning and preparedness to continue studying them would seem to be a statement of simple commonsense. However the equally common assumption that students have a single attitude towards any specific subject in the school curriculum may not be well founded. The work reported in this paper was based on the hypotheses that a student may have more than one attitude to mathematics, that primary school students in Year 5 would be able to indicate their different attitudes and that these attitudes could be measured reliably by means of a short questionnaire.

Introduction

In spite of the finding reported by Haladyna and Thomas (1979:18) that the attitude of students towards mathematics was considered to be relatively unimportant by principals and teachers in the United States, the importance of student attitudes towards the subject matter they are expected to learn in school would today be generally accepted. This acceptance stems from a predicated relationship between attitude and future learning (Mager, 1968), and from a broad acceptance that the development of favourable attitudes towards school subjects is desirable if we are concerned about the quality of life for students (Epstein and McPartland, 1976). The work reported here arises from the need for an instrument to measure the attitudes of primary school students towards mathematics.

It is pertinent to note that work on student attitudes to reading, carried out in Australia, showed that students had different attitudes to various aspects of and purposes in reading (Teale and Lewis, 1980) and that to some extent these attitudes could be distinguished by students in Years 4 and 6 at primary school (Lewis and Teale, 1982). The scales developed in this work were enjoyment, usefulness for school and vocation, and individual development. Whereas secondary students were able to distinguish these three factors in relation to reading, the primary students could distinguish only two clearly-differentiated attitudes, enjoyment of reading and valuing reading, the latter scale incorporating attitudes concerning usefulness and individual development. Consequently there was reason to expect that primary school students in Australia could also have different attitudes towards various aspects of mathematics which could be measured.

There has been considerable interest in measuring attitudes to mathematics but in most cases the nature of the measurement has been developed and used on the premise that students had an overall attitude to mathematics which could be modelled as a single dimension requiring a unitary scale for its assessment (Mastantuono, 1970; Roberts, 1970; Scharf, 1971; Fellows, 1973; Aiken, 1976). Attitudes towards different mathematics syllabus topics have also been studied (Evans, 1971), but again a single dimension of attitude was assumed. On the other hand, recent work by Kiryluk and Backhouse (1981) reported student attitudes towards mathematics on three scales, two of which, usefulness and interest, are relevant to the work reported here. This work was done with higher-achieving 14-year-old students.

Other approaches to the measurement of student attitudes towards mathematics do exist. Husén (1967) reported student attitudes towards mathematics as a process, towards the difficulty of learning mathematics and towards the place of mathematics in society. These three constructs certainly indicate a recognition of different student views about mathematics, although all are opinions about mathematics, largely dissociated from the student's personal relationship with mathematics. A fourth attitudinal measure reported by Husén, attitude towards learning

mathematics, does include the more personal aspects of liking for mathematics, preparedness to engage in mathematics, self-concept with respect to mathematics and beliefs about the usefulness of mathematics for the student. However in the work he reported, these aspects are again incorporated into a single attitudinal scale. Keeves (1966) developed a number of scales including one assessing liking, difficulty and importance of mathematics and another assessing usefulness in life and for society, and suggested that other attitudes might well be measured. Nine separate scales for the assessment of attitudes to mathematics were developed by Fennema and Sherman (1976). Their major interest was in differences in attitudes between males and females but not all of their scales were directly concerned with sex differences. Yet another approach was adopted by Haladyna, Shaughnessy and Shaughnessy (1983:20), who defined attitude to mathematics as 'general emotional disposition toward the school subject to mathematics'. In this way they excluded other dimensions frequently referred to as attitudes, and normally combined into the one attitude-to-mathematics measure.

The attitudes towards mathematics assessed in these studies generally incorporated both extrinsic and intrinsic factors concerning beliefs, expectations and affect, as evidenced by various combinations of interest, enjoyment, anxiety, confidence and perceived usefulness of mathematics on the one scale. The incorporation of the ideas of extrinsic and intrinsic factors (Deci, 1975) and the separation of beliefs, expectations and affect (Brophy and Evertson, 1981) both arise from social psychology concerned with motivation and with impressions and types of reactions to others respectively.

The Fishbein and Azjen (1975) suggestion that statements students make about mathematics can be categorized into beliefs, affects, intentions and behaviour would seem to be in this vein of thought. Similarly Aiken, who had defined two broad constructs related to attitudes to mathematics, enjoyment of mathematics and value of mathematics, expanded these constructs to form four new constructs: enjoyment of mathematics, motivation in mathematics, importance of mathematics and freedom from fear of mathematics (Aiken, 1979). However he would seem to be mainly concerned with the identification of these constructs in order to facilitate the development of a single mathematics attitude scale. The relationship of attitudes to mathematics with other school and personal variables would seem to constitute the major interest of Aiken's work (Aiken, 1976). Aiken's review also indicated that most research into student attitudes toward mathematics would seem to have been directed to secondary and tertiary levels of education (Aiken, 1976:294, 295).

The fact that many researchers have recognized different aspects of student attitudes towards mathematics in developing instruments, suggests the possibility that there may be differences in student attitudes across the various constructs identified. If there are such differences, this could account for the common finding that student attitude towards mathematics has only a modest relationship with achievement (Husén, 1967; Keeves, 1971; Aiken, 1976:295; Haladyna et al, 1983) because contrary attitudes toward different constructs subsumed in a scale could be self-cancelling.

Development of the Scales

In accepting the social psychological approach of classifying attitudes into beliefs, expectations and affect referred to by Brophy and Evertson (1981), three scales were developed. It was considered that it was on dimensions such as these that any differences in attitudes to mathematics would be exhibited. One scale, enjoyment of mathematics, had a direct link to the enjoyment of reading scale used with primary students by Lewis and Teale (1982) in that some items simply substituted mathematics for reading. Other items were written or culled from various sources including practising teachers. This scale represents the affective dimension of liking mathematics for its own sake.

A second scale which may be characterized by the statement, 'being able to do mathematics will be important if I want to get a good job', represents the expectations aspect of the classification in that the mathematics done now will be important in the future with a specific reference to vocation. Some of the items from the utilitarian reading scale were therefore appropriate for this scale after amendment. The usefulness-for-school aspect of the reading scale was not attempted in the mathematics scale development because it was considered that all students would respond that mathematics was useful for school when one of the major subjects they had to study was mathematics. Again other new items were written for this scale.

The third scale identifies one of the popular beliefs about mathematics: mathematics is useful in everyday life, outside of school. This is one specific belief which was selected for inclusion because of its importance in the rationale of primary school mathematics programs, and because it was thought that even very young students would be able to judge whether it was true for them. As the concept of everyday usefulness had not been included in the reading attitudes study, the items for this scale were written afresh.

The three dimensions of student attitudes towards mathematics that were proposed and measured were thus:

1 Mathematics is an enjoyable activity in itself (Enj Scale)
2 Mathematics is important for getting a good job (Job Scale)
3 Mathematics is useful in everyday life (Use Scale).

A total of 42 items were prepared from a variety of sources to measure the three dimensions of attitude to mathematics described above. Following Teale and Lewis (1980), a four-category Likert scale with responses of (1) Strongly agree (2) Agree (3) Disagree (4) Strongly disagree was used. Such a scale effectively forced students to agree or disagree with a statement because the only way to indicate neither was to not respond to an item. Each item was selected with the intention that it would assess students' attitudes on one, and only one, of the dimensions. The items were field tested with a total of 176 Year 5 students at 7 primary schools in Melbourne during third term 1981. They were subsequently readministered to 49 students in two of these schools two to three weeks later.

Items with which less than 70 per cent of the students consistently agreed or disagreed between the two administrations at these two schools were discarded at this time. It would seem that the consistency of students in answering these items over such a short period was too low, especially during third term when students had been taught by the same teacher all that year. For these items instability in responses was attributed to the nature of the items. Responses for the full sample of 176 students were then considered. Factor analyses were performed on the remaining items using an orthogonal Varimax rotation. Three factors had an eigenvalue greater than unity. A total of 21 items were identified which had a loading of at least 0.3 on the factor for which they were designed and a loading on this factor greater than loadings on other factors by at least 0.2. There were many other marginal items on the selection criteria used, and three of these were amended slightly before being included in the final form of the questionnaire. Thus a total of 24 items, 8 for each of the proposed dimensions of attitude was used in the study of which the measurement of attitudes towards mathematics was one strand.

Samples and Administration

The 24 item questionnaire was administered to Year 5 students in 75 classes at 39 government, Catholic and other non-government primary schools in the Melbourne area. The schools were selected at random with a probability proportional to size. The distribution of classes was such that from one to four classes were involved at each school. Most schools in the study had two classes participating.

The questionnaire was administered towards the end of February 1982 (early in first term) and then again in May 1982 (towards the end of first term). These timings were dictated by the requirements of a larger study of teachers' classroom practices. The intention was to assess student attitudes soon after they had settled down into their new Year 5 classes, and then again after one term's experience with the instructional and management practices of their new teacher. The method of administering the questionnaire involved explanation, giving a practice item and then reading an item to the students, waiting for them to make a response, and then going on to read the next item. In this way poor readers were accommodated and the pace of completing the questionnaire was controlled. The students were asked to try to answer each item but to leave it blank if they could not make up their minds in the time allowed.

Analyses

Items were first reflected as required and missing data were considered. Responses from students who had answered fewer than 12 of the 24 items were dropped from the study at this stage. Items for the remaining students were then recoded to give five categories with responses of 4 and 5 indicating a favourable attitude, 1 and 2 an unfavourable attitude and 3 being no opinion. The small remaining amount of missing data for items were coded as 3 indicating no opinion. It was considered that, at the student level, the allocation of missing data in this way was preferable to excluding students who had answered at least half the questionnaire but who had been unable to make up their minds on a few items.

The results of administering the 24 items in February were factor analyzed initially using a three-factor solution and orthogonal Varimax rotation with individual students as the unit of analysis. Again three factors had an eigenvalue greater than one. Scale reliabilities were also calculated. The three amended items again loaded on more than one factor and were dropped from the scales. Their omission also had the effect of raising the scale reliabilities. This experience served as a timely reminder that tinkering with items without further field testing rarely is a successful ploy. The remaining 21 items had good loadings on the factor for the scale for which they were devised and low loadings for the other two factors.

Table 1 Factor Pattern for 21 Items - Student Level Analysis Factor Loadings (x100) After Oblique Rotation (delta =-3.0) (Loadings > 0.3 are shown)

Item Numbers	Initial Administration			Final Administration		
	Enj	Job	Use	Enj	Job	Use
1	69			67		
4	49			62		
6	68			68		
9	81			81		
11	73			79		
14	60			60		
18	64			65		
21	57			67		
2		54			54	
5		51			52	
8		57			60	
10		69			72	
13		67			62	
15		67			68	
19		52			56	
3			55			58
7			30			38
12			58			57
16			42			46
17			58			66
20			56			65
Percent of Variance	21.4	12.3	10.5	24.9	14.6	10.5
Eigenvalue	5.06	2.58	2.21	5.22	3.07	2.20
N		1868			1829	

It was recognized that there would be a moderate correlation between the three attitude to maths scales. Consequently a factor analysis using an oblique rotation with Kaiser normalization and delta = -3.0 was performed and factor score coefficients were obtained (Nie et al, 1975:468-514). Factor loadings for each item are shown in Table 1, together with the loadings obtained from the second administration of the questionnaire in May. It will be noted that the two analyses gave very similar results. The α reliabilities of the scales were calculated (Hull and Nie, 1981:248-267) and found to range from 0.668 for the Use Scale on the first administration to 0.879 for the Enjoy Scale on the second administration (see Table 2).

Table 2 Scale α Reliabilities (21 Items)

Scale	Number of Items	Reliability	
		Initial	Final
Enj	8	0.861	0.879
Job	7	0.799	0.806
Use	6	0.668	0.738
N		1868	1829

The individual student was initially chosen as the unit of analysis in developing this questionnaire because it was recognized that attitudes are personal, idiosyncratic attributes of persons which may well differ even if, as in this case, the students in each class have been exposed largely to the same experiences with respect to mathematics. A focus on individual students seems appropriate. However, it is also of interest whether the

questionnaire developed is capable of identifying differences in attitudes between classes, if such differences do exist. It would be important to know if some types of classroom experience with mathematics were related to generally favourable attitudes and other experience related to generally unfavourable attitudes towards mathematics for most students. Consequently one-way analyses of variance were performed for the three scales using class as the independent variable and attitudes as the dependent variables (Nie et al, 1975:410-421). Differences between classes were highly significant with the variance accounted for by class membership being in the area of 10 to 20 per cent. Following use of Scheffé tests, the differences were found not to be dependent upon large differences between only a small number of classes (Nie et al, 1975:426-428).

To confirm further the appropriateness of using the questionnaire to distinguish differences between classes, items were then analyzed using the class mean as the response obtained for each item. Haladyna et al (1983:21) supported the concept of a class attitude as the mean of individual students' attitudes. The class level analyses consisted of 75 cases for the 21 mean scores for the 21 items that had satisfied the requirements of the student level analyses described above. In this case however, missing data for individual items was not allocated a code of 3 on a five-point scale. The original four-point scale was reflected so that responses of 1 and 2 indicated an unfavourable attitude and responses 3 and 4 indicated a favourable attitude. Class means for items were calculated from responses actually made by students and consequently were, in some cases, based on different numbers of students responding to items. The same method of factor analysis, also described above, was used and again three factors emerged. The factor loadings obtained are shown in Table 3. With the exception of two items, all items

Table 3 Factor Pattern for 21 Items - Class Level Analysis Factor Loadings (x100) After Oblique Rotation (delta = -3.0) (Loadings > 0.3 are shown)

Item Numbers	Initial Administration			Final Administration		
	Enj	Job	Use	Enj	Job	Use
1	79			87		
4	43			82		
6	76			78		
9	88			91		
11	87			91		
14	75			78		
18	71			76		
21	73		40	86		
2		71			71	
5		63			58	
8		76			67	
10		86			84	
13		86			76	
15		85			85	
19		77			61	
3			75			78
7			62		39	59
12			76			84
16			66			74
17			78			85
20			84			88
Percent of Variance	33.9	20.8	14.3	33.5	27.7	11.4
Eigenvalue	7.11	4.38	2.99	7.03	5.81	2.39
N		75			75	

again met the requirement of a factor loading of at least 0.3 on only one scale. The last item on the Enjoy Scale for the first administration 'Maths is mostly boring' loaded 0.40 on the Use Scale as well as 0.73 on the Enjoy Scale. The second item on the Use Scale for the second administration, 'I can get along well in everyday life without using maths', although loading 0.59 on the Use Scale, also loaded 0.39 on the Job Scale. The second item

on the Enjoy Scale 'I don't like maths', was marginal for the first administration in that it loaded only 0.43 on the Enjoy Scale and 0.29 on the Use Scale.

When α reliabilities were calculated, again using class as the unit of analysis, three items were found to be reducing the reliability of the scale to which they belonged. This was particularly true for the Enjoy Scale where the second and eighth items were again at fault. The second item on the Job Scale had a similar, though smaller, effect. However the second item on the Use Scale which was suspect as a result of its loading on the Job Scale, had a beneficial effect on the reliability of the Use Scale. It was considered necessary to have an attitude questionnaire that could be used in analyses at both the student and the class level. Consequently on balance it was decided to delete the three items reducing reliabilities for the Enjoy and Job Scales and to retain the other item increasing the Use Scale reliability. Thus the final form of the attitudes to mathematics instrument that was used consisted of 18 items, 6 for each of the Enjoy, Job and Use Scales. Reliabilities of the 6 item scales for both administrations at both levels of analysis are shown in Table 4.

Table 4 Scale α Reliabilities at Student and Class Levels of Analysis (18 items)

Scale	Number of Items	Student Level (α)		Class Level (α)	
		Initial	Final	Initial	Final
Enj	6	0.855	0.856	0.914	0.949
Job	6	0.790	0.795	0.925	0.895
Use	6	0.668	0.738	0.888	0.920
N		1868	1829	75	75

Creation of Scale Scores

Scales were created first by using factor score coefficients obtained after oblique rotation of the axes and secondly by simple addition of responses to items (that is, effectively giving each item a weight of unity). Once again it was found that there was no benefit to be gained by the more complex method of using factor score coefficients to create weighted scale scores compared with simple addition of items. All 12 product-moment correlations (three scales by two administrations by two analysis levels) between the scale scores calculated by the two methods were above 0.98 and most were above 0.99.

Finally scales were created using simple addition of item responses and correlations for each scale between the two administrations were calculated. As expected correlations were generally much higher between the two administrations of each scale than for any combination of between scale relationships, although the correlations between the initial and final administrations of the Job Scales were somewhat lower than anticipated (see Table 5).

Table 5 Product-Moment Correlations Between Scale Scores for Both Administrations at the Student Level (Above the Diagonal, N = 1868 and 1829) and Class Level (Below the Diagonal, N = 75) of Analysis. (Correlations x1000)

Scale	Initial Administration			Final Administration		
	Enj	Job	Use	Enj	Job	Use
Initial Enj		299	115	625	143	096
Initial Job	295		153	140	451	190
Initial Use	-013	275		072	142	592
Final Enj	633	023	-244		238	124
Final Job	252	394	192	296		261
Final Use	-128	276	851	-253	320	

There was relatively little missing data in responses to this questionnaire within classes. Consequently it was found that scale scores for classes differed little whether they were calculated by averaging items for classes and adding these, or by averaging scale scores for individuals within classes. However the number of Year 5 students in a class did vary considerably from 7 to 31 and the mean results for the whole sample could well vary depending upon whether each individual student's score was added separately (which would give weight to larger classes) or whether class mean scores were added (which could give equal weight to each of the 75 classes).

Table 6 Means and Standard Deviations of Scale Scores for the Total Sample of 75 Classrooms

Scale	Initial Administration		Final Administration	
	Mean	SD	Mean	SD
Enj	17.05	1.33	17.12	1.53
Job	20.08	1.07	20.45	0.94
Use	17.19	1.48	18.33	1.51

The results reported in Table 6 are means and standard deviations for each scale calculated using class means. The minimum and maximum values for each scale are 6 and 24 respectively with higher scores indicating favourable attitudes. For the Enjoy Scale it was found that a marginally favourable attitude remained virtually unchanged between the two administrations, for the Job Scale a more favourable attitude moved up only slightly, and for the Use Scale a marginally favourable attitude again moved up slightly over the period of the study. These are, of course, measures for the whole sample of 75 classes, and the expectation would be that for each dimension of attitude some classes would have declined while others would have risen over the school term.

Conclusion

The clear nature of the factor score loadings obtained for items designed or selected to measure on the appropriate scale, and the relatively high correlations between scores on each scale compared with correlations between different scales suggest that Year 5 students do have and are able to distinguish different attitudes towards mathematics. The scales were also found to be sensitive to differences between classes. The reliabilities found for the three six-item scales indicate that enjoyment of mathematics, the expected importance of mathematics for employment and the perceived usefulness of mathematics in everyday life can be measured with reasonable reliability using a short questionnaire which may be analyzed at either the student or class level.

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