Measurement of Attitude to Mathematics

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Discussions about the nature of mathematics learning typically include both cognitive and affective variables such as attitude. As part of his comparison of mathematics achievement in a number of different countries Husen [1967] collected data about students' attitude to mathematics. Books reviewing research in mathematics education [see, e.g., Shumway, 1980] invariably include an overview of findings concerned with students' attitude to mathematics. The comprehensive Cockcroft [1982] report that considered the teaching of mathematics in primary and secondary schools in England and Wales also devoted a number of sections to attitude to mathematics. Models of mathematics learning such as those proposed by Fennema and Peterson [1985] and Tsai and Walberg [1983] provide further evidence of the importance attached to attitude as a factor influencing achievement.

The agreement about the need to consider attitude to mathematics as an important factor in mathematics learning is not mirrored in the way it is measured. A host of different instruments have in fact been used. Some [Aiken, 1972; Anttonen, 1969; Fellows, 1973; Scharf, 1971] illustrate an underlying assumption that students have an overall, single dimensional attitude to mathematics which can be measured on a unitary scale. Other, more recent approaches [e.g., Fennema and Sherman, 1976; Haladyna, Shaughnessy and Shaughnessy, 1983; Tsai and Walberg, 1983] recognize explicitly different aspects of students' attitude to mathematics and report the effects of the different components separately.

To understand why such a variety of instruments to measure attitude to mathematics has been developed it is essential to consider the definition and measurement of attitude in a broader context.

In their influential work, Thomas and Znaniecki [1918] argued that social psychology should be defined as the scientific study of attitudes. According to them, an attitude is

> a process of individual consciousness which determines real or possible activities of the individual in the social world
> [Thomas and Znaniecki, 1918, p. 22]

Since attitude cannot be observed directly but must be inferred from observable behaviour, it would be remarkable indeed if in the ensuing almost seven decades a single definition of attitude had been universally adopted and retained unchanged. In fact, over the years many definitions of attitude have been proposed. Particularly influential have been the ones put forward by Thurstone [1928] and Allport [1935]. The former indicated that

> the concept of "attitude" will be used here to denote the sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats, and convictions about any specific topic. [p. 532]

Allport [1935] defined attitude as follows:

> An attitude is a mental and neural state of readiness, organized through experience, exerting a directive and dynamic influence upon the individual's response to all objects and situations with which it is related. [p. 810]

The important features of these definitions have been retained in later "consensus" definitions of attitude, as can be seen from the following examples.

> A definition that includes many of the central ideas used by attitude theorists would be as follows: "An attitude is an idea charged with emotion which predisposes a class of actions to a particular class of social situations." [Triandis, 1971, p. 2]

> Most investigators would probably agree that attitude can be described as a learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object. [Fishbein and Ajzen, 1975, p. 6]

The latter definition in particular highlights four crucial assumptions: attitude is learned, it predisposes to action, the action towards the object is either favourable or unfavourable, and there is response consistency. Instruments commonly used to measure attitude to mathematics reflect these cognitive, behavioural, and affective or evaluative components of attitude to various degrees. Attempts to close the gap between the definition and measurement of attitude continue to the present. Lalljee, Brown, and Ginsburg [1984] in a recent paper rejected the conceptualization of attitudes as enduring internal affective predispositions with a causal influence on behaviour, or as behaviour in their own right. Instead they "construe attitudes as communicative acts which imply favourable or unfavourable evaluations about a class of objects, persons or events" [p. 239]. Because of the difficulties involved in matching the conceptualized components of attitude to their operational

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definitions and their quantification through measurable aspects of behaviour, such efforts are likely to continue.

It is inappropriate to spell out here the various common areas of disagreement or concern among those involved in attitude research. It is useful, however, to note some of those issues of particular relevance to the measurement of attitude to mathematics, e g., the extent to which attitude actually affects behaviour; how well the various attitude measurement instruments describe behaviour (self report paper-and-pencil instruments have most frequently been used to measure attitude and, as Kiesler, Collins, and Miller [1969] point out, these do not make use of overt behaviour); the extent to which attitudes are affected by the context in which they are measured; the extent to which attitudes are learned and hence the extent to which they are affected by other variables; and the extent to which an attitude is made up of separate components. Concern with some or all of these issues is reflected in instruments devised to measure attitude to mathematics.

It is possible to distinguish a number of broad categories into which different attitude measure can be divided. As has already been indicated, most common are self report measures. Other approaches described by Cook and Selltiz [1964] involve drawing inferences from observing overt behaviour in a natural setting, from considering an individual's reaction to or interpretation of partially structured stimuli, from an individual's performance on 'objective' tasks, and from the physiological reaction of respondents to the attitudinal object or a representation of it. All these approaches serve a useful purpose provided the measures used are both valid and reliable, i.e., they are based on an appropriate conceptualization of attitude, correlate highly with another valid measure of attitude towards the same object, and yield comparable results at different administrations

After this general discussion it is appropriate to examine in more detail the important characteristics of the different methods that have been used to measure attitude to mathematics. For maximum clarity, for each method discussed a representative example found in the relevant mathematics education literature is also provided.

The techniques considered in this paper are similar to those selected by Gardner [1975] in his review of attitude to science. However, because of their infrequent use in research on attitude to mathematics, rating scales in which the respondent is asked to rate self or others with respect to a single item only are not considered. Included instead are the use of physiological measures to infer attitude to mathematics. The following techniques will thus be considered: Thurstone scales, summated rating scales exemplified by (the most common) Likert-type scales, semantic differential scales, interest inventories and check lists, preference ranking, projective techniques, enrolment data, other forms of data gathering such as clinical and anthropological methods, and physiological responses. While the majority of these techniques are examples of self report, paper-and-pencil measures, and thus fall into Cook and Selltig's [1964] first category, examples of instruments in their other categories are also included.

Thurstone (equal-appearing interval) scales

Example: Dutton's [1962] attitude to arithmetic scale

Selected items: I avoid arithmetic because I am not very good with figures.
I think about arithmetic problems outside of school and like to work them out

Development of a Thurstone scale requires a number of steps. In the first instance a pool of items, reflecting a continuum of attitude to arithmetic, say, is written. A group of "judges" is then asked to place these items in one of (typically) 11 piles, with the items considered most favourable to be put into the first pile, the least favourable into the last pile, and the other items in between, as deemed appropriate. A scale value (the mean or median of the ratings assigned by the judges) can thus be calculated for each statement. Those to which the judges assign widely differing ratings are omitted from the final scale. Once developed, respondents to whom the scale is administered are asked to identify those items with which they agree. The mean or median of the scale value of the items selected represents each respondent's attitude score.

Critics of Thurstone's approach have questioned his assumption that the judges' own biases would not influence their ratings. The alternate scaling procedure suggested by Likert overcomes this problem

Likert Scales

Examples: Aiken's [1972] mathematics attitude scale is an example of a single dimensional scale, while the Fennema and Sherman [1976] mathematics attitude scales are an instrument that can be used to assess different components of attitude to mathematics

Selected items: SD D U A SA
When I hear the word mathematics, I have a feeling of dislike
I am sure that I can learn mathematics.

Collecting a large pool of items indicating either a positive or a negative attitude to mathematics, say, is the first step in constructing a Likert scale. While items indicating a neutral attitude are appropriate for a Thurstone scale, they are eliminated from a Likert scale. Subjects to whom the scale is administered are asked to indicate, typically on a five point scale ranging from strongly agree to strongly disagree, their response to the items. Strong agreement and disagreement with favourable items are scored as 5 and 1 respectively. Appropriate ratings are given to the intermediate responses. Scoring is reversed for unfavourable items. On the assumption of unidimensionality, i.e., that all the items measure the same construct, the subjects' attitude is defined as the sum of the item scores. Items that do not correlate significantly with the overall attitude score are not retained. After trial, the (twenty or so) items with the highest correlations form the Likert scale. The sum of the scores obtained on the items denotes the subjects' attitude to mathematics

The construction of the Fennema and Sherman [1976] scales represents not the first, but certainly a particularly influential departure from an unacceptably simplistic approach to the measurement of attitude to mathematics. Their scales make explicit the authors' conceptualization of attitude to mathematics as comprising a number of components, which can best and most meaningfully be reported separately. Their approach illustrates their assumption that other factors including the respondent's perception of mother's and father's attitude to mathematics, the respondent's attitude towards success in mathematics, and the perception of mathematics as a male domain are important components of a multi-dimensional conceptualization of mathematics attitude.

(Osgood's) Semantic differential scale

Example: Scholfield and Start's [1978] semantic differential scale to measure attitude to mathematics

Selected items:

mathematics	
worthwhile	trivial
easy	difficult

The semantic differential technique was originally developed by Osgood, Suci, and Tannenbaum [1957] as an instrument to measure meaning. It consists of a number of stimulus words or concepts to which subjects respond by indicating the position on the line between two bipolar adjectives (such as good/bad; masculine/feminine) that best reflects their feeling about that item. A seven point rating scale is commonly used. The ratings are combined and analyzed in various ways to describe the respondent's attitude. Factor analysis typically reveals that three basic dimensions underlie the common explainable variance. They are evaluation, potency, and activity.

The value of the technique depends to a large extent on the suitability of the stimulus words or concepts chosen, as well as on the relevance to them of the bipolar adjectives selected.

The semantic differential is often regarded as a less transparent, more indirect measure of attitude than the other measures discussed so far.

Inventories and checklists

Example: Fox and Denham's [1974] use of the Vocational Preference Inventory to determine occupational preferences of a group of mathematically talented students; Leder's (note 1) use of the Adjective Check List (ACL) [Gough & Heilburn, 1965] to tap stereotypes of outstanding mathematics students.

Typical Item: A list of occupations
A list of adjectives

Inventories and checklists are two other examples of subjective rating scales. The former typically consists of a list of careers, activities, hobbies, or adjectives. The respondent is asked to indicate items of particular interest.

Adjective check lists are commonly used to obtain self-descriptions or to elicit stereotypes about groups of people (say, outstanding mathematics students). Respondents are asked to indicate the adjectives they consider most applicable to themselves, or to the target group, as appropriate. Recent use of the ACL by this writer [Leder, note 1] to tap stereotypes among different samples of outstanding mathematics students yielded highly consistent results.

Preference rankings

Example: Herman [1963], children's ranking of school subjects.

Typical Item: A list of school subjects, to be ranked in order of preference.

As indicated above, preference ranking requires students to list the subjects they study at school in order of preference. The rank assigned to mathematics is thus obtained. As noted by Gardner [1975], the relative nature of the measure imposes limitations. A student with a very favourable attitude to school could put mathematics last, and yet have a more positive attitude to mathematics than another student who ranked mathematics first.

Projective techniques

Example: Leder [1982], in a study examining the relationship between attitude and achievement in mathematics.

Typical Item: Request for a written response, in terms of certain prompt questions, to a cue such as "Anne came top of her mathematics class last term."

Projective techniques represent an indirect approach to the measurement of attitudes. To be effective they therefore rely less on the honesty and co-operation of respondents than do more explicit methods. Projective techniques may involve sentence completion ("a good mathematics lesson..."), a word association test, a picture preference test, or a request to tell a story in response to a cue such as the one described above. Because of the difficulty of ensuring satisfactory validity, reliability, and particularly consistent scoring of projective measures, they are not used often as measure of mathematics attitude. Nevertheless, responses to the partially structure stimuli can provide powerful insights into respondents' attitude.

Enrolments

Example: Fennema, Wolleat, Pedro, and Becker [1981]

Typical Item: Statistics on enrolment in mathematics courses

A number of factors, including a positive attitude to mathematics, are generally assumed to influence students' decision to continue with mathematics courses once they are no longer compulsory. Haladyna *et al* [1983], for instance, argued that "a positive attitude toward mathematics may increase one's tendency to elect mathematics courses in high school and college." [p. 20] Their interpretation rests on a willingness to accept a decision to continue with a course, say mathematics, as a measure of attitude to mathe-

matics. A similar interpretation is prevalent in studies that consider sex differences in mathematics learning. However, because of the widely recognized role of mathematics prerequisites as a critical filter into other course, apprenticeships and occupations the importance of other variables are likely to outweigh the attitude to mathematics component as a determinant of mathematics course taking.

Other forms of data gathering: clinical and anthropological observations

Example: Eynard and Walkerdine [1981] who observed children in a nursery school in spontaneous play.

Typical Item: Observations of overt behaviour in a natural setting.

Attitude to mathematical activities has also been inferred from observations of young children engaged in spontaneous play. Eynard and Walkerdine [1981], for example, noted that boys of preschool age chose more construction play and play with sand and water activities, while girls were more likely to be involved in fantasy and creative play. Sex linked differences in attitude to mathematics have been linked to such differences in the preferred play activities of boys and girls. Recent research on the effects on student attitude of small group instruction in a number of subject areas, including mathematics [Lockheed and Harris, 1984], has also relied on natural observation techniques.

Physiological measures

Example: Dreger and Aiken's [1957] study of mathematics anxiety.

Typical Item: Measures of electrical skin resistance

Physiological indicators (electrical skin resistance, breathing rate, blood pressure, heart rate) of attitude to mathematics have been found in a number of research studies. Because of the difficulties associated with obtaining these measures their use is likely to remain limited.

The variety of instruments used to measure attitude is highlighted by Fishbein and Ajzen's [1972] review of research published between 1968 and 1970. They identified more than 500 different methods considered as measures of attitude. While many of these would not be appropriate for use in the mathematics area, those interested in the measurement of attitude to mathematics nevertheless have a wide selection of instruments from which they can choose. In many cases, authors either implicitly or explicitly define attitude to mathematics in terms of the instrument(s) used in their research. Allport's claim, made in 1935, that "attitudes today are measured more successfully than they are defined" [quoted in Dawes, 1972, p. 2] continues to be applicable. Each technique is potentially useful, provided the instrument is well designed and theoretically sound. Findings that are confirmed in studies using different instruments can be accepted with greater confidence. Ultimately only those measures that reflect a widely acceptable conceptualization of attitude to mathematics and that yield consistent findings are likely to be retained.

Reference note

1. Leder, G.C. Beliefs about mathematically gifted students. Paper presented at the second National Conference on Gifted and Talented Students. Brisbane, Queensland, Australia, May 15-18, 1984

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