ACCESSING STUDENT AFFECT: STRATEGIES AND CONCERNS

ANDREA MCDONOUGH
Mathematics Teaching and Learning Centre
Australian Catholic University

DAVID CLARKE
Faculty of Education
University of Melbourne

ABSTRACT

While mathematics curriculum developers have attended carefully to issues of content coverage and even to models of cognition, the same attention has not been accorded to student affect. The planning of instructional and assessment practice seldom includes consideration of such factors as student motivation, confidence, satisfaction, or self-esteem. It should be stated at the outset that we do not endorse the partitioning of human behaviour into affective and cognitive as mutually exclusive categories. For the purpose of the present discussion, however, we find the term "affect" useful to describe those behaviours conventionally associated with emotive response.

This paper adopts the position that it is essential that curricula attend to student affect in an explicit and structured way. Strategies, developed for research purposes, offer the possibility of accessing student affect in classroom situations. The use of these strategies raises all of the familiar issues of construct and content validity, and, most importantly, the contemporary concern with consequential validity. The use of the term "access" in the title to this paper is intended to foreshadow the need to distinguish between "measurement" and "portrayal". We find the term "measurement" to have unfortunate uni-dimensional connotations, and for the purposes of this paper would like to advocate the use by researchers and teachers of the term "portrayal" in relation to the process of data collection regarding student affect. Approaches to the portrayal of student affect are discussed and illustrated by reference to the results of studies employing instruments with the capacity to access student affect.

INTRODUCTION

Recent major publications on mathematics teaching and learning (for example, Australian Education Council, 1991; Grouws, 1992; National Council of Teachers of Mathematics, 1991) include reference to both the affective and cognitive aspects of mathematics learning. There is an increasing awareness in the mathematics education community of the importance of studying both cognitive and affective aspects when exploring our understanding of children's learning of mathematics (Leder, 1993a). While cognitive aspects of learning have received research attention for some period of time, interest in the affective domain has been more recent (McLeod, 1992). The work of Fennema and Sherman (1976) was a major early contributor in the study of attitudes to mathematics particularly in terms of the study of gender differences in mathematics education. An important aspect of their research was its focus on attitude as a multi-dimensional factor, including perceptions about mathematics, oneself, and one's teacher, father and mother.

The multi-dimensionality of the affective domain (McLeod, 1992) is reflected in the different aspects focused upon in a range of major documents. Appreciation and enjoyment of mathematics (Australian Education Council, 1991; Cockcroft, 1982) and the notions of self-esteem and success (Victorian Ministry of Education, 1988) are facets of the affective domain which are believed to be of importance in children's learning of mathematics. The National Council of Teachers of Mathematics (1991) in speaking of promoting students' mathematical disposition included the attributes of confidence, flexibility, perseverance and curiosity. There is also great variation in variables researched within affect, for example, as demonstrated in a recent review of publications by researchers within the Psychology of Mathematics Education group (Leder, 1993a).

While the different facets of the affective domain are recognised as important in current research, they perhaps also have contributed to the difficulty of defining just what is meant by attitudes, or the affective domain, or whatever term or terms one chooses to use (Hart, 1989; Leder, 1993a; McLeod, 1992). Psychology and mathematics education sometimes have different meanings for terms (Hart, 1989) and even within mathematics education, studies which use the same terminology may not be studying the same phenomenon (McLeod, 1992).

For the purpose of this paper, the general term 'affect' as used by McLeod (1992) and Fennema (1989), is deployed. This term is taken to encompass a range of aspects including attitudes, emotions, and particular beliefs. The term 'attitudes', while sometimes used to include beliefs about oneself as a learner and about mathematics, is employed most commonly in relation to liking, disliking and related preferences (McLeod, 1992).

While beliefs, attitudes and emotions encompass a range of affective responses, it can generally be assumed that beliefs and attitudes are stable in nature. Emotions are considered as 'hot' reactions which can change rapidly (Mandler, 1989). Each of these three affective responses also differs in the degree to which a cognitive component is involved in its formation: "We can think of beliefs, attitudes, and emotions as representing increasing levels of affective involvement, decreasing levels of cognitive involvement, increasing levels of intensity of response, and decreasing levels of response stability" (McLeod, 1992, p. 579). The approaches reported in this paper to access student affect vary in nature, and focus mainly on children's affective beliefs, an aspect of some stability, but also offer scope for investigation of other aspects of the affective domain.

There are moves in the mathematics education research community to give an integrated perspective between cognitive and affective variables (Leder, 1993a), just as these two sets of variables can be seen to be closely linked in the reality of the classroom (for example, Clarke, 1987). Current initiatives directed at relating cognitive and affective variables appear to interpret the present need as the establishment of the interconnectedness of two distinct forms of human response: the cognitive and the affective. It is also possible to locate cognitive and affective responses within the functioning of a single "unified" dimension of belief. This interpretation of the cognitive and the affective as manifestations of the same underlying process warrants discussion.

From the "unified" perspective, the two statements: "Mathematics is boring" and "The sum of the angles in a triangle is 180 degrees" are both statements of belief. The distinction between these two statements does not lie in whether one is a statement of empirical fact and the other one of opinion. Both personal opinion and empirical fact (as interpreted by the person making the statements) could be invoked as justification for either statement.

The dichotomization of learning into cognitive and affective has seen a bifurcation in the curriculum, in assessment practice, and in research, in which cognitive beliefs and the associated enactment of these beliefs have been privileged in comparison with affective beliefs. This paper illustrates the inadequacy of that dichotomization, and presents strategies for accessing those behaviours and ideas which have come to be called "affective". Central to the purpose of this paper is the observation that data collection strategies designed to collect "affective" data frequently collect "cognitive" data, and that open-ended prompts designed to collect "cognitive" data also generate responses in the "affective" domain. It will be argued that only recently have instruments been employed, of a sufficiently non-coercive nature, for the interrelatedness of the "affective" and the "cognitive" to emerge.

THE RESEARCH STUDIES

The following studies are characterized by their use of instruments intended to access student affect. Brief details are provided regarding the context of each study. Only those results or methodological points pertinent to this paper are reported. The interested reader is referred to the full report of each study cited.

The Interactive Monitoring Program for Accessing Children's Thinking (IMPACT)
During 1984, 753 Year 7 pupils in 36 mathematics classes in 15 Victorian secondary schools were regularly given the opportunity, about once every two weeks, to give confidential, written answers to questions like:

What was the best thing to happen in Maths during the last two weeks?
What was the biggest worry affecting your work in Maths?
What would you most like more help with?
What is the most important thing you have learned in Maths during the last two weeks?
Write down one new problem which you can now do.
How do you feel in Maths classes?
How could we improve Maths classes?

This study was concerned primarily with the efficacy of the IMPACT procedure as a mechanism for the classroom monitoring of student learning (Clarke, 1987). The evaluation involved the collection of thousands of student responses to the questions above. Whichever particular question was being addressed, student responses were as likely to mention those things conventionally labelled affective, as they were to deal with those labelled cognitive. Some illustrative examples of this diversity are provided below.

Item: Write down the most important thing you have learned in Maths during the past two weeks.

- It's not that important, but I'm glad we went over division of fractions.
- Pronumerals - I don't really think I've learnt anything very important to me. Because I don't like maths. SORRY.
- Not to let your friends tell you what's going to be in a test.
- I'm stupid in class.

Item: What is the biggest worry affecting your work in Maths at the moment?

- I am not sure but I always seem to do something wrong in my graphs but cannot work out what I am doing wrong.
- Keeping up with the rest of the class.
- My dad has been away for six weeks now in a war exercise overseas in Europe.

The Interactive Mathematics Project (IMP - California)

An evaluation of the first year of implementation of the Interactive Mathematics Project (Clarke, Fraser & Wallbridge, 1992) focussed upon the "other consequences of a problem-based mathematics curriculum". The subjects of this study were drawn from three Californian high schools implementing the Interactive Mathematics Project with some of their Year 9 pupils. In the report, reference is made to three groups of students: i) 180 IMP students - mean age 15.3 years; ii) 126 Algebra 2 students - mean age 15.4 years; iii) 137 Algebra 4 students - mean age 16.9 years. In this study, two instruments were employed to access student perceptions, beliefs and attitudes.

Mathematics belief questionnaire.

The mathematics belief questionnaire was adapted from an instrument employed to measure the student belief outcomes of an innovative program employing student journals (see Clarke, Waywood, & Stephens, 1993). Every item had been validated through interviews with students. Minor changes in phrasing were made for administration in American schools.

Some sample items were:

1. If I had to give myself a score out of 10 to show, honestly, how good I think I am at math, the score I would give myself would be ...

3. The ideas of mathematics

A. Have always been true and will always be true	Agree	Disagree
D. Developed as people needed them in everyday life	Agree	Disagree
F. Are most clearly explained using numbers	Agree	Disagree

5. When I am doing mathematics at school, I am likely to be

A. Talking	Always	Often	Sometimes	Seldom	Never
C. Writing words	Always	Often	Sometimes	Seldom	Never
F. Working with a friend	Always	Often	Sometimes	Seldom	Never
I. Listening to other students	Always	Often	Sometimes	Seldom	Never
K. Working from a textbook	Always	Often	Sometimes	Seldom	Never

7. An adaptation of the IMPACT instrument (Clarke, 1987), including such sub-items as:
   Write down one new problem which you can now do.
   What is the biggest worry affecting your work in math at the moment?
   How could math classes be improved?

Mathematics world questionnaire.

The mathematics world questionnaire was adapted for American administration from an instrument employed in a study of community perceptions of mathematical activity (Clarke & Wallbridge, 1989). In this questionnaire, students were asked to indicate whether they thought specific everyday activities were highly mathematical, quite mathematical, slightly mathematical, barely mathematical, or not mathematical.

The activities listed included:

4. Cooking a meal using a recipe
7. Playing a musical instrument
9. Buying clothing at a sale

It was argued by Clarke, Fraser and Wallbridge (1992) that the most significant outcomes of student participation in the Interactive Mathematics Project did not lie in the marginal achievement gains identified, but in the distinctive set of beliefs relating to the origins of mathematics, to the operation of mathematics in everyday life, and to the manner in which mathematics is learned most effectively. The Interactive Mathematics Project was also distinguished by the attitudes to school mathematics and the relatively high level of self-esteem reported by participant pupils in comparison with conventionally taught students at the same year level and from the same schools.

Pupil Perceptions of Effective Learning Environments in Mathematics (PPELEM)

PPELEM (Pupil Perceptions of Effective Learning Environments in Mathematics), has been developed in two formats: the questionnaire (McDonough, 1992) and the interview (McDonough, 1993). The former was developed and used by McDonough (1992) in the study of learning environment preferences of a sample of 427 children taken from a population of 1245 children from grades one to six from nine Melbourne schools.

Data were collected from whole classes through administration of the instrument by the class teacher. Children responded to the instruction "Think of a situation in which you are learning maths well. Draw it, show the people, the things around you and what you are doing." by drawing a picture of their chosen situation.

A description of the situation was elicited through a student questionnaire. The questionnaire response informed the researcher of factors such as the location of the depicted situation, for example, school, home, or other; of what people were in the picture; of the presence or absence of a adult; and of the use of any tools or other materials. The questionnaire also asked children to identify what it was in the situation that was most helping them to learn maths well.

Reflection on the findings of the study resulted in the conclusion that the 'what was most helping you to learn' factor had not been developed to a satisfactory degree. In a current study, PPELEM is being utilised in its interview form. In this version (McDonough, 1993), children are given the instruction as above, but for both "learning mathematics well" and for "not learning mathematics well". It is believed that the child's provision of an example of an ineffective learning situation may give further insights into the perception of factors which facilitate learning.

Following the instruction children draw a picture and then describe their picture. While the child is doing this the interviewer writes on cards what seem to her as the key words from the child's description. At the conclusion of the description the words are shown to the child and there is the opportunity for deletion or addition of words to describe the key things in the child's situation as drawn and described. The child is then asked to complete a culling and rank ordering (Salmon, 1977) of the factors, indicating those which are perceived to have most helped (hindered) to least helped (hindered) them to learn mathematics well in that situation.

This use of PPELEM in the interview format allows intensive discussion not only of what factors children perceive most to affect their learning of mathematics but also discussion of why these are considered to be important factors. In this respect the interview version allows greater insight into children's perspectives than does the questionnaire version.

The Personal Dictionary and "Maths is like ..."

An instrument titled *Personal Dictionary* was developed (McDonough, 1993), to give some insights into the meaning children give to mathematics and learning. This instrument is suitable for use in an interview situation. The procedure is outlined below.

The child is asked whether she knows what a dictionary is and to describe what it gives or has in it. The replies given in interviews with a grade five and a grade six child were to the effect that it is a book with words and their meanings.

The interview continues with the child being told she is to pretend that she is writing her own personal dictionary with her own meanings of words in it. The child is then asked for meanings she would give for words such as 'house' and 'pet', and for their personal meaning for the word 'learning'. In the trialling one child replied: "someone getting to know something new"; the other stated: "to be taught something".

The interview continues with the child being asked to tell of something she has learnt recently. This interview proceeds as a conversation in which the child is asked questions such as how she came to learn in the situation she relates.

This then leads to further questions which stem from the child's responses, seeking further insights into words or key concepts which the interviewee associates with learning. For example, when one child spoke of practise in her learning of a new song on the piano she was asked whether the word practise would go in her personal dictionary. Through the conversation the words "understand" and "remember" also were identified as relevant by this child. The other interviewee in the trialling process identified "remembering" and "someone teaching you" as words which would be in his personal dictionary entry for learning. For the latter child there was some indication of the importance of an instructor of some kind. In contrast the other child showed a tendency toward regarding learning as an independent activity. In the *Personal Dictionary* task there is also discussion of children's personal meanings for 'mathematics'.

Another related instrument investigating children's perceptions of mathematics utilises a prompt commonly found in exploration by classroom teachers (McDonough, 1993). Children are asked to complete the sentence beginning "Maths is like ....". The response given in one of the two trials with this instrument demonstrates the potential for instruments to bring to light the intensity of children's views related to both the "cognitive" and "affective" aspects of mathematics learning. The strength of personal feelings is conveyed in a statement written by a grade 5 child:

> Maths is like .... a fun activity but it is also a job we have to do. I like maths because it really makes you think about what you're doing. At other times maths is like a weed that grows and grows when I'm having a bad day. Maths is changing and the better you get at it the harder it gets. The things we do are quite fun. I like maths.

In contrast a reply from another interviewee related not to the affective side of mathematics but only to the cognitive side. He wrote:

> Maths is like .... adding dividing timising & takerwaying. waying things mezering distenses.

The reference by pupils to matters that would conventionally be labelled affective and cognitive, in response to the same cue, supports our contention that the dichotomization of affect and cognition is in error.

DISCUSSION

Leder (1993b) argues, in relation to attitudes to mathematics there is a range of components. She states that attitudes have a cognitive component (they are learnt), a behavioural component (attitudes predispose towards action) and an evaluative component (the actions may be favourable or unfavourable). As attitudes can be said to be what people think, feel about, and how they like to behave toward an attitude object (Leder, 1993b, Taylor, 1993), a consensus is emerging within the mathematics education community that there can be seen significant overlap between attitudes, emotions and beliefs (Leder, 1993b). The perspective offered in this paper advocates the use of "beliefs" as the unifying dimension within which "affective" and "cognitive" behaviours can be located, studied, and explained.

In what can be seen as further support of the argument that the affective and cognitive domains are inextricably linked, Fennema and Peterson have developed their Autonomous Learning Behaviour Model (Fennema, 1989), in relation to gender differences in mathematics, which proposes that internal belief systems impact upon mathematics outcomes. This model has been generalised (Fennema, 1989) to the population of male and female learners of mathematics, retaining the proposed relationship between the affective domain and mathematics outcomes.

The instruments and techniques described in this paper are intended to improve one's "ability to hear the students and to construct models of the learning process as perceived by students" (Lindenskov, 1993, p. 149). The learning process is a complex one, with teachers and pupils being individuals who differ in many ways including their beliefs, attitudes, and perceived needs. It is in the quest to gain new insights into the personal perspective of learners in the mathematics classroom that the issues discussed in this paper have been raised.

It is particularly in the area of assessment practice that the privileging of those responses and processes labelled as "cognitive" has been most explicit. Contemporary assessment practices (Clarke, 1989) offer new insights into the interrelationship of previously dichotomized "affective" and "cognitive" responses. Acknowledgement of the centrality of "affective response" in the understanding and promotion of learning through explicit assessment practice has been advocated recently (Clarke, 1994). It is in the assessment practices of the mathematics education community that the implications of this reconception of the affective-cognitive dichotomy are likely to prove most significant.

Belief systems have become an area considered to be of interest and importance in research on problem solving (Schoenfeld, 1985; Silver, 1985), with one result being the proposition that belief systems lie on the border between affect and cognition. We would like to suggest that belief systems can be considered to encompass both cognitive and affective functions, and that the identification of the authority on which an individual's belief is based offers significant insight into that individual's learning. The most useful distinction between the two statements "Mathematics is boring" and "The sum of the angles in a triangle is 180 degrees" can be found in the location of the authority to which the individual appeals in substantiating either assertion. It is the location of the authority on which a belief is held that provides the more useful insight into the thinking of the learner, teacher, student, individual; rather than the categorization of a statement as either cognitive or affective. This matter warrants further research.

REFERENCES

Australian Education Council. (1991). *A national statement on mathematics for Australian schools.* Carlton, Victoria: Curriculum Corporation.

Clarke, D.J. (1987). The interactive monitoring of children's learning of mathematics. *For the Learning of Mathematics, 7*(1), 2-6.

Clarke, D.J. (1989). *Assessment alternatives in mathematics.* Carlton, Victoria: Curriculum Corporation.

Clarke, D.J. (1994). Promoting learning through the assessment of student affect: Who cares? Invited address to the 1994 Annual Meeting of the National Council of Teachers of Mathematics, Indianapolis, April 13 - 17, 1994.

Clarke, D.J., Fraser, S., & Wallbridge, M. (1992). *The other consequences of a problem-based mathematics curriculum. Research Report No. 3.* Oakleigh: Mathematics Teaching and Learning Centre.

Clarke, D.J., Waywood, A., & Stephens, M. (1993). Probing the structure of mathematical writing. *Educational Studies in Mathematics 25*, 235 - 250.

Clarke, D.J. & Wallbridge, M. (1989) How many mathematics are there? In B. Doig (ed.) *Every One Counts.* Parkville: Mathematical Association of Victoria.

Cockcroft, W. H. (1982). *Mathematics counts.* London: Her Majesty's Stationery Office.

Fennema, E. (1989). The study of affect and mathematics: A proposed generic model for research. In D.B. McLeod & V.M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 205-219). New York: Springer-Verlag.

Fennema, E. & Sherman, J. (1976). Fennema-Sherman mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. Abstracted in the *JSAS Catalog of selected documents in psychology, 6*(2), 31.

Grouws, D.A. (Ed.), (1992) *Handbook of research on mathematics teaching and learning.* New York: MacMillan.

Hart, L.E. (1989). Describing the affective domain: Saying what we mean. In D.B. McLeod & V.M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 20-36). New York: Springer-Verlag.

Leder, G. (1993a). Reconciling affective and cognitive aspects of mathematics learning: Reality or a pious hope? *Proceedings of the Seventeenth International Conference for the Psychology of Mathematics Education: Vol 1* (pp. 46-65). Tsukuba, Japan: Program Committee of the 17th PME Conference.

Leder, G. (1993b). Attitudes to mathematics (Editorial). *Mathematics Education Research Journal 4*(3), 1 - 7.

Lindenskov, L. (1993). Exploring the student's own mathematics curriculum. In J.A. Malone & P.C.S. Taylor (Eds.), *Constructivist interpretations of teaching and learning mathematics. Proceedings of Topic Group 10 at the Seventh International Congress on Mathematical Education (ICME-7)* (pp. 149-156), Quebec, Canada, August, 1992.

Mandler, G. (1989). Affect and learning: Causes and consequences of emotional interactions. In D.B. McLeod & V.M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 3-19). New York: Springer-Verlag.

McDonough, A. (1992). *Pupil perceptions of effective learning environments in mathematics* (Research Report No. 5). Oakleigh: Mathematics Teaching and Learning Centre.

McDonough, A. (1993). Investigating children's beliefs about themselves as learners of mathematics. Paper presented to the colloquium "Research Processes in Mathematics Education", held at Monash University, November, 1993. Proceedings to be published.

McLeod, D.M. (1992). Research on affect in mathematics education: A Reconceptualization. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). New York: MacMillan.

National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics.* Reston, Virginia: NCTM.

Salmon, P. (1977). Grid measures with child subjects. In P. Slater (Ed.), *Measurement of intra-personal space Vol. 1* (pp. 15-46). London: John Wiley & Sons.

Silver, E.A. (1985). Research on teaching mathematical problem solving: Some underrepresented themes and needed directions. In E.A. Silver (Ed.). *Teaching and learning mathematical problem solving: Multiple research perspectives* (pp. 247-266). Hillsdale, NJ: Lawrence Erblaum Associates, cited in McLeod (1992).

Schoenfeld, A.H. (1985). *Mathematical problem solving.* Orlando, FL: Academic Press.

Taylor, L. (1993). Mathematical attitude development from a Vygotskian perspective. *Matheamtics Education Research Journal 4*(8), 8 - 23.

Victorian Ministry of Education (1988). *The mathematics framework: P - 10.* Melbourne: Ministry of Education, Victoria.