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THE PERSONAL CONSTRUCTION OF TEACHING AND MATHEMATICS TEACHER EDUCATION

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Introduction

With the expansion of schooling in the 1950s and 1960s there was a consequent flurry of curriculum activity. More pupils stayed longer at school and schools had to cater for a wider range of abilities and interests. New curricula were developed, old curricula revised to provide educational programmes for the changing clientele, and many curriculum projects initiated, covering all aspects of schooling. By the 1970s these curriculum projects had been evaluated and the evaluations provided new insights into the whole curriculum process. One insight of particular interest concerned the role of the teacher. What the teacher did in the classroom was central to the whole curriculum process; no curriculum was teacher-proof. In particular, what were the teacher's views on, and beliefs about, teaching in general and teaching specific subjects in particular? (Howson, 1976; Fey, 1979).

This last realisation came at a time when there was beginning to be a change in emphasis in the study of the curriculum process. The procedure for developing a curriculum, first formalised by Tyler (1948) and elaborated by Taba (1962) and Wheeler (1967), saw the role of the teacher in such procedures to be that of a compliant technician. Any decisions the teacher made were of a low order, concerning presentation of material using techniques determined by the curriculum project designer. The significant change in emphasis in the study of the curriculum process was initiated by Schwab (1970) with his call for 'the art of the practical' in studying the curriculum process. This was followed by the suggestion that the teacher should be his own curriculum developer and conduct his own curriculum research (Stenhouse, 1975). The changing role of the teacher, from a passive to an active, central role was also beginning to be emphasised in teacher preparation courses (Lawton *et al.* 1978). Another suggestion concerned procedures whereby teachers could enhance their active role in the curriculum process by developing 'education connoisseurship' (Eisner, 1979); the teacher was now seen as central to the whole curriculum process.

The problems now facing those studying the curriculum process was to find out what teachers actually did in their classrooms. Very little seemed to be known about the teacher as a person, holding a unique set of values and beliefs that could be useful in explaining teachers' classroom behaviour.

Research on teaching in the 1960s had used observation of classroom events by instruments which yielded quantified data. This research was concerned with the relationship between two categories of variables, processes (teaching) and products (pupil behaviour): the process-product model (Gage, 1963; Hilgard, 1964). In the 1970s new research procedures began to develop and current procedures were refined (Travers, 1973). A distinction was made between teaching as classroom management and teaching as instruction (Nuthall and Snook, 1973). The latter was subject-specific, being seen as the interaction among teacher, pupil *and* subject content being taught. Another two categories of variables were included in the model of teaching used to guide research on teaching (Dunkin and Biddle, 1974): presage variables and context variables.

Related to these last suggestions is a survey on managerial decision-making for classrooms (Doyle, 1979) that suggested that teachers used a schema, a hypothesis-testing model, to assist them in the conscious processing of classroom information. Hargreaves (1979) suggested that through examination of the commonsense knowledge, skills and values of teachers a basic model for teaching could be provided. In Australia, similar directions for research on teaching have been suggested (Hogben, 1980; Crane, 1979) as they have been in England (Eggleston, 1979).

Research on Mathematics Teaching and Mathematics Teacher Education

The search for significant teacher *presage* variables described above has concentrated on teaching as classroom management. Has there been a similar trend in research on teaching as instruction? Teaching as instruction is subject specific, so an answer might be sought in

research on mathematics teaching. Two recent surveys can be noted: Begle (1978) and Cooney (1980). Begle (1978), after surveying the empirical literature on research on teaching, listed what he considered were the critical variables in mathematics education. Sixty-nine studies of teachers' classroom behaviour were examined and the tentative conclusion reached was that while studies of teacher classroom behaviour should continue, to date research had not shown teacher classroom behaviour to be a reliable indicator of teacher effectiveness. Begle found that the teacher's age, sex and knowedge of mathematics seemed to have little bearing on student achievement (the only reliable index of effectiveness for him) but he did not exclude teacher behaviour and attitudes from the set of critical variables in mathematics education. Cooney (1980) used a four element interaction model: the teacher, the context, the content and the student. Studies of teaching in general were examined to see if they had any implication for mathematics teaching. The variables in teaching behaviour were placed in one of three categories: affective, cognitive, managerial. Cooney pointed out that the variables so far revealed by research on teaching were inferential: their existence was inferred from classroom observation. High inference variables were the result of large inferential 'leaps' between observed teacher behaviour and student action. Low inference variables resulted from statistical analysis of quantified observations of teacher behaviour.

This last survey went on to ask if there is a body of pedagogical knowledge existing which can be deemed important enough to be included in a mathematics teacher education programme and stressed that student teachers need to be given a framework of basic pedagogical concepts to guide their reflections on, and analysis of, mathematics teaching. The source of such concepts should be the commonsense decisions of successful teachers: Davis' (1967) 'practitioners' maxims'. Research into mathematics teaching should go to experienced teachers, beginning teachers and trainee teachers to seek such knowledge. Experienced teachers have pedagogical knowledge and attitudes which have been successful over the years. A study of beginning and trainee teachers would show what changes occur in their perspective of teaching mathematics as the preservice and initial teaching experiences accumulate. Doing this 'could go a long way in providing and understanding of the dynamics of teacher education and the means by which teachers acquire perspectives about teaching' (Cooney, 1980).

In suggesting this research on mathematics teaching, and mathematics teacher education, Cooney is accepting the change in emphasis in research on teaching in general. In addition, he is picking up a suggestion made by Davis (1967), and elaborated by Bishop (1971), concerning research on mathematics teaching. Davis (1967) suggested that research on mathematics teaching needed to analyse teacher belief systems as a source of relevant data and an appropriate methodology to collect data could be that of the clinician, the counsellor, the psychoanalyst: teaching is an art and the first place to look for data which can help to analyse the practice of this art is in the 'practitioners' maxims'.

Belief Systems, Practitioners Maxims and Personal Construct Psychology

Against the above background, work now some twenty years old saw the development of approaches derived from the personal construct psychology of George Kelly (1955). Recently an outline and review of the approach has been published as *Personal Construct Psychology and Education* (Pope and Keen, 1981). Kelly's theory stresses 'individual-meaning-giving', the manner in which persons are not simple information-reception devices but rather project meaning into situations and events. This 'meaning' is *individual* (though consistency across individuals occurs and provides the basis for social relations and role-playing) and is organised into a *system* (a system of core and peripheral constructs) that is *complex*. Thus, in relation to any situation, event, or domain of experience, one would expect a particular individual to have a more or less personal interpretation which was more or less complex. There may be 'core' constructs which the person could not change or could only change with great difficulty, as well as peripheral or only core constructs in relation to the particular domain. Out of Kelly's (1955) original formulations various specific methodologies developed and the literature is usefully summarised by Fransella and Bannister (1977). Essentially these methodologies represent sorting tasks which enable a person to indicate the way in which persons order their world or some domain of their experiences.

Just how are these complex structures of meaning represented? Fortunately a number of statistical packages are available for the analysis of the 'grids' of constructs and elements that form the basic data. The techniques and their theoretical bases are documented by

Slater (1976, 1977). In general terms the raw data are correlated and reduced to a number of components that account for more or less of the variation in the grid. An identification is allowed of the manner in which a particular person orders the domain of experience under investigation. Onto a diagrammatic representation of the major components (usually two or three exhaust the major part of the variance) can be mapped the *elements* used; such that not only the way in which the domain is given meaning, but also the way in which persons, roles etc. relevant to that domain are construed, is made clear. Thus, one might be interested in examining the way a teacher construes the teaching relationship and the nature of the processes involved in a particular teaching subject, and whether this matches or mismatches the constructions of pupils or the class as a whole. The range of applications of the personal construct approach is wide and extends from understanding psychopathology to determining change (and presumably effectiveness) of psychotherapy, from developmental and learning studies to management styles (Fransella and Bannister, 1977).

The Study

Intention

The present study had several purposes. The first was to determine two central aspects of Kelly's (1955) theory: that a person's construing in the teaching situation and relationship will be *individual* and *complex*. A second purpose was to examine, within the context of individuality and complexity, just how a number of common assumptions, beliefs, or established notions (constructs) about teaching (particularly mathematics teaching where the subject matter is highly structured) are in fact held and related to one another by individual students preparing to be teachers; and how these are used to construe individuals involved in various phases of the development toward being a teacher — the presage variables of Dunkin and Biddle (1974). A third purpose was to consider the usefulness and general meaningfulness of the task required to 'get at' these other aspects; that is, to confirm a methodology. Diamond (1983), using slightly different methods had already shown the value of research conducted within the general personal-construct framework; the present study, preliminary to some longitudinal and cross-sectional interests of the *development* of constructs, sought to add additional material to his suggestions and to extend from the general to the more subject-specific. Finally, we were concerned to place the foregoing observations in the context of teacher preparation. If developments in philosophy of science do sweep away much of the positivist-empiricist methodology, personal construct psychology might emerge as a timely and well-developed alternative methodology in this context.

The Instrument

Thirty dichotomous constructs were formed, guided by the literature relating to teaching, and in particular to mathematics teaching. For example: confident-anxious, talks-listens, innovative-conservative, teacher corrects-pupils correct work; and, anyone can learn maths — only the intelligent can learn maths, best mathematicians are verbalisers — best mathematicians are visualisers, maths is a set of concepts and logical procedures — maths is merely one way of organising the world, maths is more easily learned by convergent thinkers — maths is more easily learned by divergent thinkers. *Fifteen* elements were used that in terms of the same guidelines appeared to exhaust the likely influences on a trainee teacher: four specific persons (the Curriculum and Method lecturer, another Diploma in Education lecturer, a practice-teaching supervisor, the master in charge of the Maths Department in the practice-teaching school); eight role-titles to be filled-in individually by each student (best and worst teachers maths and non-maths, university lecturers maths and non-maths, a student colleague, any other person influential in an individual's decision to be a teacher): two personal referants (myself as a teacher, myself during practice-teaching); and 'the ideal teacher'. Fifteen pages, each containing the forty constructs arranged in a five-point Likert format, and headed by a different element, were formed into a booklet which was prefaced by a cover sheet containing instructions. The task was to indicate on the scale whether a particular element fell towards construct or contrast pole. To facilitate the task and to make better sense grammatically of some of the elements and constructs, words like 'is, or would think or feel that' were added after elements; such that a question would read as 'Your Curriculum and Method lecturer is, was or would think or feel: confident/teaching is an art/anyone can learn to do maths, etc.

Subjects

Twelve students, 3 male 9 female, in the Mathematics Curriculum and Method group in the end-on Diploma in Education course at

the University of Newcastle completed the form individually after their practice-teaching session. Students were all volunteers who had been asked in advance to think of persons who filled the role titles.

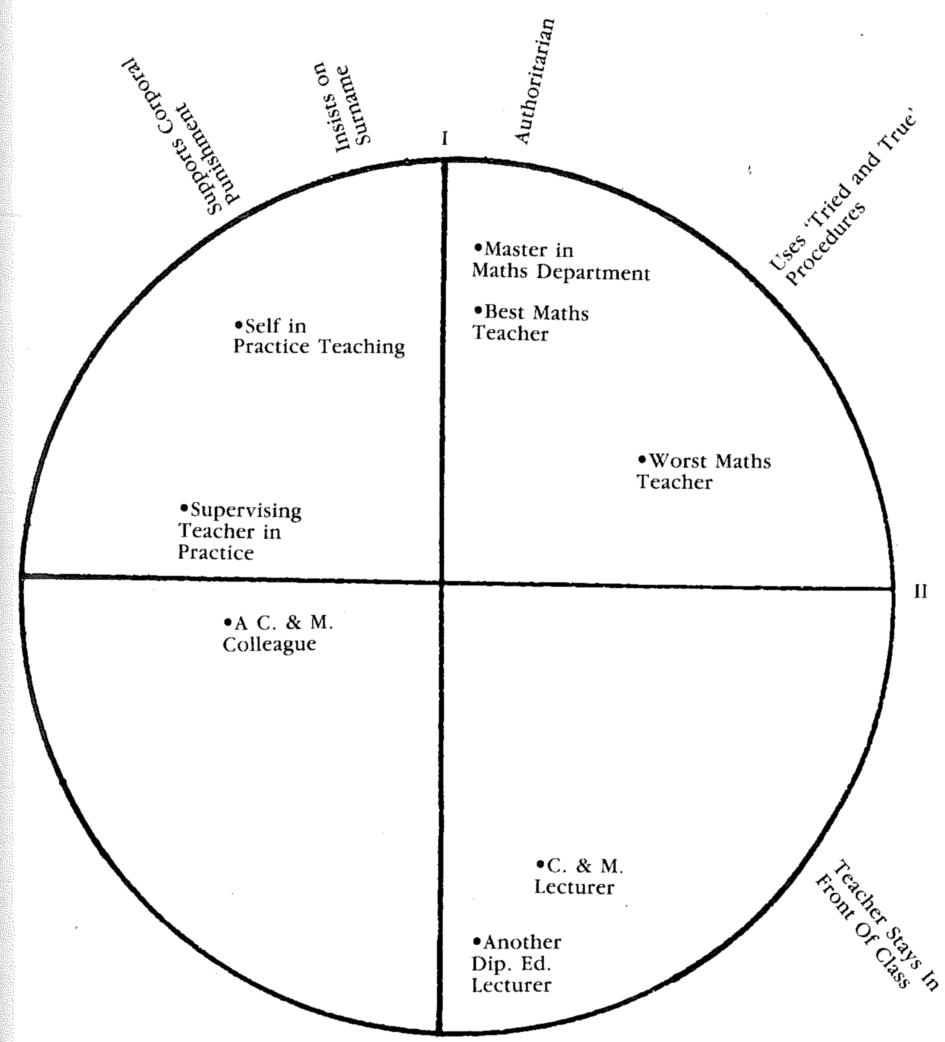

Figure One: Representation of Component One (24%) against Component Two (21%) and position of elements in relation to constructs forming those components.

Results

Results for each subject were separately analysed using Slater's (1976) INGRID programme. This programme takes each grid of elements (15) and constructs (30) and performs a Principal Components Analysis. Three components were extracted in each separate analysis and these accounted for 58% of the variation in the lowest case, and 78% in the highest; two results are shown here for illustrative purposes: Figure One for the grid from which the lowest amount of variance was accounted for the three components; Figure Two in which the highest amount of variance was accounted for. In these figures showing Component One mapped against Component Two, those elements loading on a component at 3.00 loading or higher are taken into account. It is useful to consider the figures separately.

Figure One: Component One (24%) was associated with constructs authoritarian, supporting corporal punishment and insisting on the use of surname. This was used to construe the best maths teacher, the master of the Maths Department in the practice teaching school and to a minor extent 'myself during practice teaching', and to contrast the Curriculum and Method lecturer, and another Dip. Ed. lecturer involved in teaching skills. Component Two (21%) was associated with the teacher standing in front of the class and using tried and true procedures. Here the element 'worst maths teacher I have known' loaded highest and was contrasted with 'a supervising teacher during practice teaching', 'a student C & M colleague', and 'myself during practice teaching'. Component Three (13% only and not shown on the Figure) was associated with pupils following set procedures, learning better when they sit still and listen, and setting-out work in correct mathematical form. Here 'worst mathematics teacher' was contrasted with 'best mathematics teacher'.

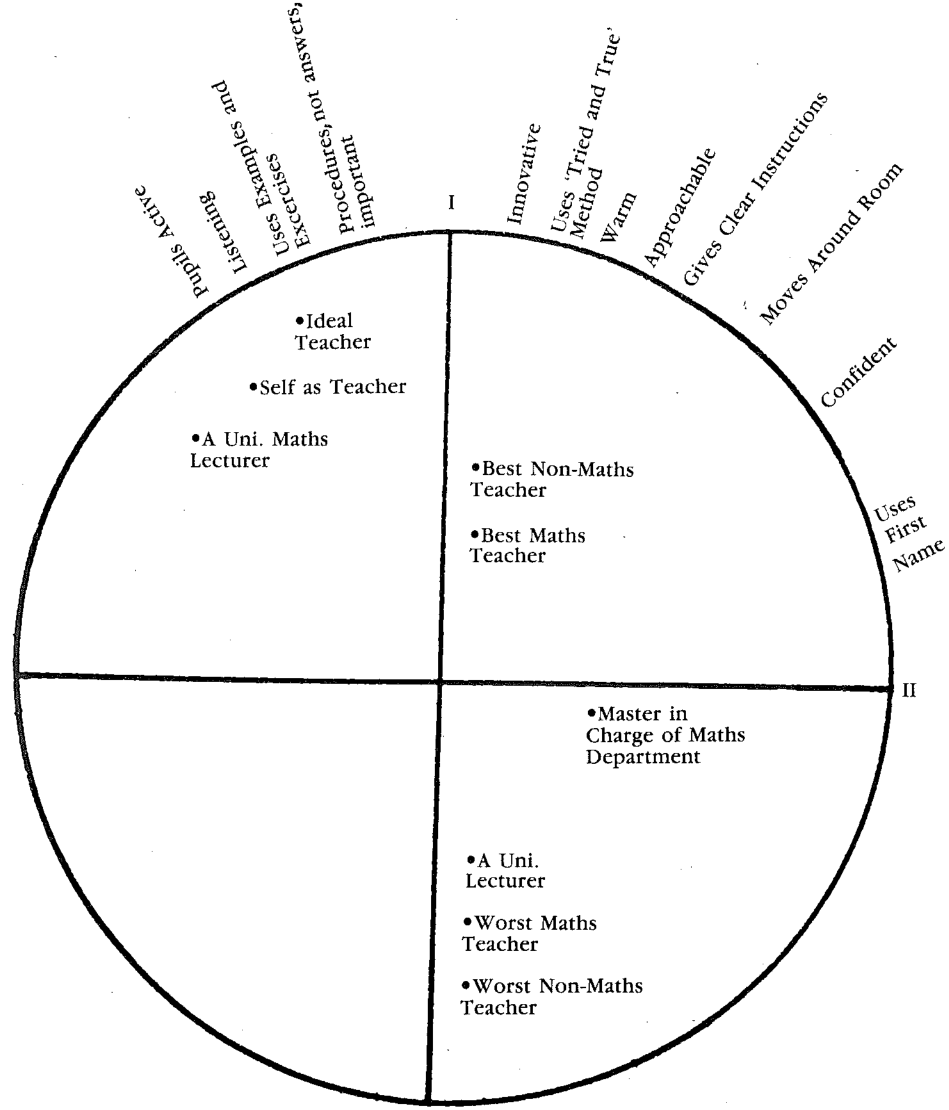

Figure Two: Representation of Component One (55%) against Component Two (14%) and position of elements in relation to constructs forming those components.

Figure Two: Component One (55%) was associated with warmth and approachability, listening (rather than talking), using a few tried and true procedures but being innovative in method, being clear with instructions, giving individual help and allowing pupils to help each other, stressing procedures not correct answers, moving around the class and involving pupils, and beliefs that pupils learn from examples and exercises (rather than copying facts) and that learning is better when pupils are actively engaged in using materials. Here construed in these terms were elements 'best teachers' both mathematics and non-mathematics, a university mathematics lecturer the subject had known, 'myself as a teacher' and 'the ideal teacher'. Contrasted with these on this component were elements 'worst teacher' mathematics and non-mathematics, another university lecturer the subject had known, and a supervising teacher during practice teaching. Component Two (14%) was associated with warmth and the use of first name and was used to construe the master in charge of the mathematics department in the practice-teaching school and to contrast the worst non-mathematics teacher. Component Three (9%) had no loadings approaching the criterion.

The correlations between constructs were examined for each of these same two sets of results. When a construct correlates highest with another, which other correlates highest with the first, a relation of *mutual* implication is taken as a reasonable assumption. When a construct correlates highest with another, which other correlates highest and third, a one-way relationship is suggested. On this basis sets of 'strings' of constructs are derived and may be noted for each of the two subjects under consideration.

Subject One: Here five *mutual* implications were apparent; 'innovative' implied radical, 'giving clear instructions' implied students correct all work, 'democratic' implied opposes corporal punishment, 'warm' implied approachable, 'anyone can learn maths' implied pupils should be allowed flexibility rather than be forced to set out work in correct mathematical form. Other relations of interest, not *mutual* implications here, were that 'teaching is an art' implied radical, 'uses first name' implied democratic, 'using many different techniques' implied innovative, as did the belief that maths was intrinsically useful rather than its main value in getting a job.

Subject Two: Here four *mutual* implications emerged: 'using many different techniques' implied innovative, 'conservative' implied only the intelligent can do mathematics, 'stress on the correct answer

rather than the procedure used' implied maths was not 'useful', and 'teacher standing in front of the class' implied lecturing and use of the blackboard. Other relations of interest were that 'confident' implied warm, which implied approachability, which latter was also implied by the opposition to corporal punishment.

Interpretation

The figures illustrate well our present contentions. Two subjects, presented with a set of constructs and elements pertaining to a domain that was highly relevant to their present situations, are able to use some of those constructs to construe some of those elements, and display wide variation in the extent to which they use the constructs. Subject One is relatively less complex, with the main component comprising of only a small number of constructs revolving around a general orientation that might apply to any situation, not clearly or specifically to teaching. Moreover, when applied in the teaching context it appears stereotypic and overgeneralising: authoritarianism is associated with simple factors like insisting on use of the surname and supporting corporal punishment. Component Two relates more to specific teaching style and suggests conservatism and inflexibility. Again, this component is associated with only a small number of constructs, and it is a 'negative' construct in that the worst mathematics teacher the subject has known is associated with this component, and 'myself in practice teaching' seen as quite opposite to it. Interestingly, the ideal teacher is not construed in terms of any of the thirty constructs presently used — this subject is unable or unwilling to use any of the present constructs to give meaning to such an element. However, 'myself in practice teaching' has been construed in terms of the second component and the 'discrepancy' would suggest a relatively low self-evalution of performance.

Subject Two, by contrast to Subject One, uses many more of the constructs and evidences a different pattern of meanings. Here the major component is concerned with both general teaching factors and more specific techniques and beliefs across a wide range. This subject has a cluster of constructs concerned with 'good teaching' and is able to rate a number of individuals with whom there has been contact, in terms of these constructs. Also construed in this way is 'myself in practice teaching' and 'the ideal teacher', suggesting a confidence and high esteem factor in the teaching situation in that there is not the same discrepancy or distance between these two elements as was the case for Subject One.

Group Results

Examination of the analyses for the whole group showed that in one-third to one-quarter of cases two constructs were not used by the subjects: best mathematicians are verbalisers — best mathematicians are visualisers; mathematics more easily learned by convergent thinkers — mathematics more easily learned by divergent thinkers. In addition, there are no constructs which formed part of the first component for every subject, though three constructs: democratic-authoritarian, warm-cold, in front of class-moves around the room, loaded on the first component in 50% or more of the cases. When this same observation is made for Components One and Two together, one of those constructs, in front of class-moves around the room, was accounted for in 75% of the cases.

Beyond this visual analysis of individual grids for comparison, Slater's (1977) programme SERIES provides an analysis which enables a consensus grid to be formed and analysed. These analyses were performed and the outcome is shown in Figure Three. In the consensus grid 84% of the variance was accounted for by the first three components.

Figure Three: Here the first component involves seven constructs: being clear with instructions, being approachable and warm, using many different teaching techniques, moving around the room rather than standing in front of the class, questioning and involving students, and being innovative in method. Located in terms of these constructs is the 'best mathematics teacher' the group has encountered as well as the 'ideal teacher' and 'myself during practice teaching'. Contrasted with these are the 'worst teachers' both in mathematics and non-mathematics. The second component is less clear and is represented by one construct: insistence on surname; though the practice of 'moving around the room' also loads moderately. Only two elements are construed in these terms, both lecturers involved in the group's teacher preparation course, who are contrasted with these practices. The third component is related to clarity of instructions, standing in front of the class, being confident and talking (rather than listening). The element associated

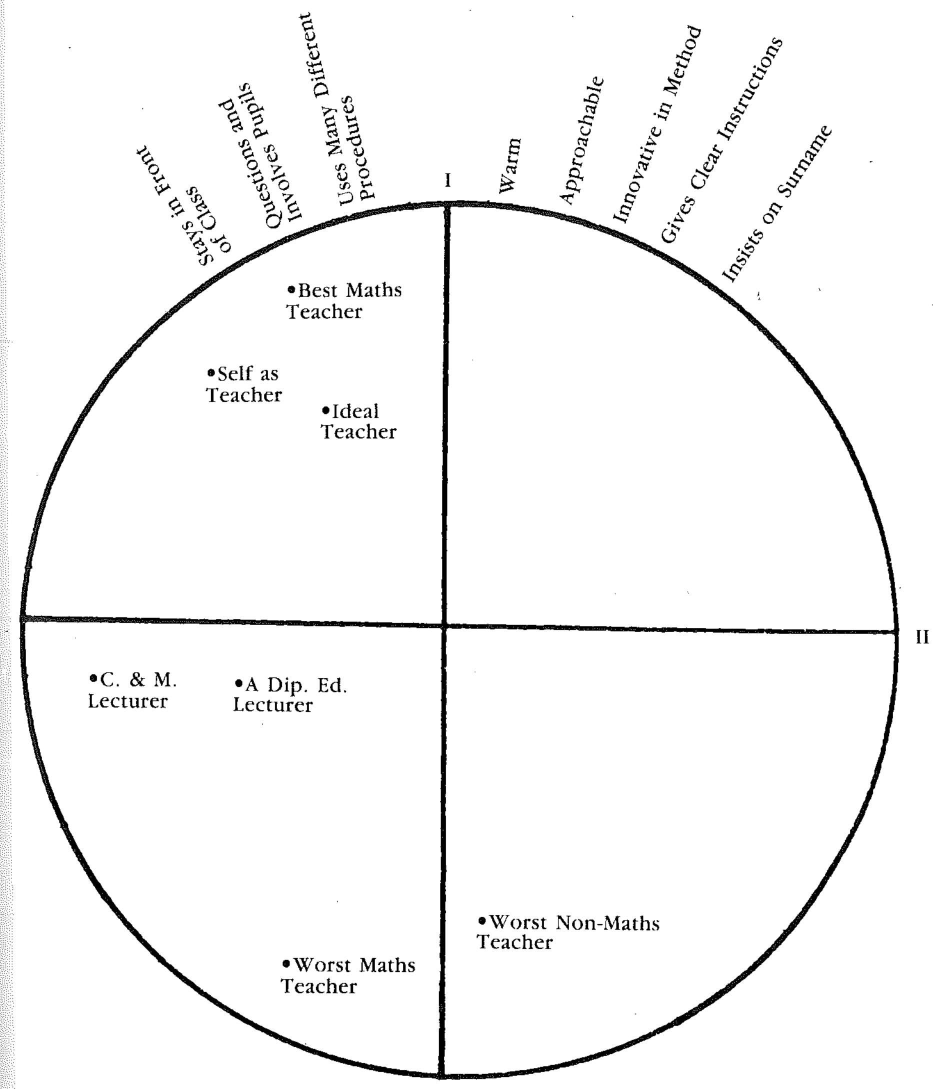

Figure Three: Representation of Component One (60%) against Component Two (17%) and position of elements in relation to constructs forming those Components (Loadings here are at 2.0 or higher).

with this component is 'the master in charge of the mathematics department in the practice teaching school'.

Correlational analysis, as before, indicated six relationships of mutual implication: 'confidence' implied giving clear instructions, 'warmth' implied approachability, 'using many different techniques' implied innovativeness, 'democratic' implied problems were solved by intuition not by set procedures, 'teaching the class as a group' impled standing in front of the class, and 'believing that maths has many uses' implied belief that maths helped in getting a job.

Interpretation

What is apparent from Figure Three is the extent to which general features of teaching are given significance by the group, just as they were by individual members of that group considered in Figures One and Two; that is, it is features of the *general* teaching relationship or situation that have relatively greater significance than features of the subject-matter presently focused. The group has a clear construal of the type of characteristics that go with good teaching, does not distinguish a bad teacher from a bad mathematics teacher on the present constructs, and has a clear view of how they wish to be perceived, or perceive themselves, as teachers generally.

Conclusions

The foregoing observations fit well with the purposes of the present study. There is individual variation in the manner and in the extent to which different constructs are used by different individuals to give meaning to the teaching relationship and situation; the methodology has been shown to be a meaningful one and to generate intelligible patterns. These patterns of meaning, moreover, have implications for understanding the manner in which student-teachers see the teaching relationship and situation, and in turn, implications for teacher preparation and the subsequent development of skills and effectiveness.

Student teachers do not categorise their past experiences of teaching, or their current experiences in practice teaching, as classroom management *or* instruction. Teachers who have taught them, teachers with whom they work during practice teaching, are 'the best' or 'the worst' for a range of reasons. The reasons given for classifying teachers as such, given in personal and private interviews with their supervisor, fall along a continuum. At one end is their view of the teacher as a classroom manager, at the other end is their

view of the teacher as an instructor. In fact, some rudimentary positioning by the supervisor during the interview, using the purely qualitative assessment of teachers by students, tended to fall into a two-dimensional pattern using the two aspects of teaching as axes. This technique was taken from the work done by MacPherson *et al*, (1971). The work was in some ways akin to the construct and element spaces produced by the INGRID analysis. For student teachers, teaching was a seamless, cohering activity initially, with classroom management and instruction being interdependent. Using personal construct techniques to investigate teaching could help students themselves to tease out the complex relation which seems to exist between classroom management and instruction. The techniques could delineate the basic pedagogical concepts and hence provide a conceptual framework to guide the student teacher in analysing, and reflecting on, teaching. In these observations we are in total agreement with Diamond (1983), whose interest was less subject-specific.

In relation to this last observation, it may be useful to split those constructs that pertain to mathematics from those pertaining to the general teaching situation. This would allow a more precise indication of whether and how some quite complex ideas (beliefs about the contrast between verbalisers and visualisers in mathematics, for example) are dealt with by these students. A second suggestion might be to move to the practice of *deriving* constructs from student-teachers themselves, rather than supplying constructs derived from the literature as in the present case (cf. Larking, 1981). Interactive routines are now widely available to facilitate such elicitation (Pope and Keen, 1981; Pope and Shaw, 1981).

More generally, however, there is scope to extend the present approach into the area of teaching and teacher preparation, to examine the construction systems of experienced teachers, and to consider the changes in construction systems that might occur with increased experience in and of the teaching situation. The approach trialled in the present study appears timely, given both the attacks on empiricist approaches and the general shift in emphasis noted in our introductory comments. Moreover, there is some evidence that despite the relative absence of the personal construct approach it is of interest to researchers directly (Diamond, 1983) or indirectly (Larking, 1981; Marsh and Huberman, 1982) . This general approach might, in turn, prove more fruitful for the development of a general theory of pedagogy and the types of differentiations, if any, made between different subject areas.

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