Teacher Beliefs About the Learning and Teaching of Mathematics: Some Comparisons

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During the last four years, a survey instrument was administered to 603 primary and 336 secondary teachers in both government and Catholic schools across an urban and a rural school region in New South Wales. This paper reports on comparisons concerning the espoused beliefs about mathematics, mathematics learning and mathematics teaching of the teacher respondents and demonstrates significant differences between the teachers across the regions, types of school and gender.

Introduction

This report continues the research agenda presented at MERGA 17 (Perry & Howard, 1994) which set the basis for investigations of primary and secondary teachers' use of manipulatives (Howard, Perry & Conroy, 1995; Howard, Perry & Conroy, 1996; Howard & Perry, 1997; Howard, Perry & Tracey, 1997) and their espoused beliefs about mathematics, mathematics learning and mathematics teaching (Perry, Howard & Conroy, 1996; Howard, Perry & Lindsay, 1997). Evidence suggests that such beliefs play a major role in determining how teachers teach (Barnett & Sather, 1992; Pajares, 1992; Weissglass, 1992). The focus of this paper is the comparison of the espoused beliefs of primary and secondary mathematics teachers across identified demographic variables.

Teacher beliefs about mathematics, mathematics learning and mathematics teaching

The development of beliefs about the nature of mathematics and how mathematics is done "*are important not only because they influence how one thinks about, approaches, and follows through on mathematical tasks but also because they influence how one studies mathematics and how and when one attends to mathematics instruction*" (Garofalo 1989, p. 502). Critical to the classroom implementation of the learning and teaching of mathematics is the teacher and, in particular, the beliefs of the teacher. All teachers of mathematics hold beliefs about mathematics, mathematics learning and mathematics teaching. These beliefs influence and guide teachers in their decision making and implementation of teaching strategies (Baroody, 1987)

Teachers' espoused beliefs about mathematics, mathematics learning and mathematics teaching fall along a continuum from a traditional teacher-centred point of view where the teacher is seen to be the deliverer of knowledge and skills ("transmission") to a view where children play a central role in constructing their own mathematics ("child-centred") (Anderson, 1996; Cobb, 1988; Yackel & Cobb, 1996; Kuhs & Ball, 1986). Such a continuum has been used by the authors to profile the beliefs held by primary school teachers (Perry, Howard & Conroy, 1996) and secondary teachers (Howard, Perry & Lindsay, 1997).

Methodology

The data for this investigation were collected using a specifically designed questionnaire covering the following areas:

1. subject demographics such as gender, age, position in school, nature of teacher training, length of teaching experience, class(es) currently taught, class size, classes taught over the last ten years;
2. use of manipulatives in mathematics learning and teaching such as which are used, why and how they are used, and the areas of mathematics in which they are used;
3. beliefs about mathematics, mathematics learning and mathematics teaching.

The questionnaire relied on the self reporting of the teachers, paralleling much of the work reported in Hatfield (1994), and was administered over 1995, 1996 and 1997 to the samples described in Table 1. All schools involved in the study were located in either the south western suburbs of Sydney or the north coast of New South Wales.

Year	School level	School type	Number of Schools	Responses received
1995	Primary	Government	25	252
1996	Secondary	Government	37	198
1996	Secondary	Catholic	15	51
1997	Primary	Government	114	244
1997	Primary	Catholic	32	107
1997	Secondary	Government	23	44
1997	Secondary	Catholic	12	43

Table 1 Number of schools surveyed and number of responses

In all cases, the questionnaire was posted, with reply paid envelopes, to the Principals of the schools after first making telephone contact to obtain their initial approval to undertake the survey in the schools and to ascertain the number of primary teachers or secondary mathematics teachers in each school. In the secondary schools, telephone contact was also made with the Head Teacher (Mathematics).

Data from these responses were analysed using the SPSS-X program to provide descriptive statistics for the demographic data and the use of manipulatives and comparative statistics regarding teacher beliefs about mathematics, mathematics learning and mathematics teaching.

For this paper, a confirmatory factor analysis was employed to confirm the authors' a priori predictions of the clustering of the beliefs items used in the questionnaire related to the continuum (transmission to child-centredness) of teachers' mathematical beliefs. Analysis of variance was used to investigate the data in relation to these two factors across the demographic variables.

Results

Confirmatory factor analysis

To gather data concerning teachers' espoused beliefs about mathematics, mathematics teaching and mathematics learning, an instrument consisting of twenty statements was designed following an extensive literature review (Perry, Howard &

Conroy, 1996) (see Table 2). A three-point Likert response scale - 1 (disagree), 2 (undecided) and 3 (agree) - was used with these statements. Hence, higher scores indicate more adherence to the particular belief represented by the statement.

Mathematics

▲ 1. Mathematics is computation
▲ 2. Mathematics problems given to students should be quickly solvable in a few steps
● 3. Mathematics is the dynamic searching for order and pattern in the learner's environment
4. Mathematics is no more sequential a subject than any other
● 5. Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking
▲ 6. Right answers are much more important in mathematics than the ways in which you get them

Mathematics learning

● 7. Mathematics knowledge is the result of the learner interpreting and organising the information gained from experiences
● 8. Students are rational decision makers capable of determining for themselves what is right and wrong
▲ 9. Mathematics learning is being able to get the right answers quickly
● 10. Periods of uncertainty, conflict, confusion, surprise are a significant part of the mathematics learning process
● 11. Young students are capable of much higher levels of mathematical thought than has been suggested traditionally
▲ 12. Being able to memorise facts is critical in mathematics learning
● 13. Mathematics learning is enhanced by activities which build upon and respect students' experiences
● 14. Mathematics learning is enhanced by challenge within a supportive environment

Mathematics teaching

● 15. Teachers should provide instructional activities which result in problematic situations for learners
▲ 16. Teachers or the textbook - not the student - are the authorities for what is right or wrong
▲ 17. The role of the mathematics teacher is to transmit mathematical knowledge and to verify that learners have received this knowledge
● 18. Teachers should recognise that what seem like errors and confusions from an adult point of view are students' expressions of their current understanding
● 19. Teachers should negotiate social norms with the students in order to develop a cooperative learning environment in which students can construct their knowledge
20. It is unnecessary, even damaging, for teachers to tell students if their answers are correct or incorrect

Table 2 Beliefs statements
▲ denotes that the item loads significantly on "transmission"
● denotes that the item loads significantly on "child-centredness"

A priori predictions were made about how these statements would cluster around the factors of transmission and child-centredness. A confirmatory factor analysis, using principal axis factoring and an oblique rotation solution method, was conducted. Using a criterion of > .30 (or < - .30) for the significance of a factor loading, it was found that the 7 items marked ▲ in Table 2 loaded significantly onto one factor - "transmission" and the 11 items marked ● in Table 2 loaded significantly onto the other factor - "child-centredness". Items 4 and 20 did not load significantly on either factor. This analysis confirmed the a priori predictions of the pattern of clusters among the items, hence, providing construct validation for the measure.

Demographic data

There were 939 respondents - 603 primary and 336 secondary teachers. Data concerning the location and types of schools in which the respondents taught are given in Tables 3 and 4. Table 5 shows the gender composition of the sample.

School level / Sector	Catholic	Government
Primary	107 (18%)	496 (82%)
Secondary	94 (28%)	242 (72%)

Table 3 Composition of sample by sector (N = 939)

School level / Location	North Coast	South Western Sydney
Primary	351 (58%)	252 (42%)
Secondary	87 (26%)	249 (74%)

Table 4 Composition of sample by location (N = 939)

School level	Female	Male
Primary	458 (76%)	143 (24%)
Secondary	138 (41%)	198 (59%)

Table 5 Composition of sample by gender (N = 939)

The majority of respondents had 6 or more years of teaching experience, as shown in Table 6.

School level	< 1 year	1 - 5 years	6 - 10 years	11 - 20 years	> 20 years
Primary	13 (2%)	89 (15%)	105 (17%)	199 (33%)	197 (33%)
Secondary	9 (3%)	45 (13%)	57 (17%)	116 (35%)	108 (32%)

Table 6 Teaching experience (N = 939)

The school positions held by the respondents in both primary and secondary schools are reported in Table 7.

School level	Principal / DP / AP	Other executive / Head Teacher (Maths)	Classroom teachers	Other teachers
Primary	120 (20%)	54 (9%)	366 (61%)	59 (10%)
Secondary	10 (3%)	67 (20%)	247 (74%)	11 (3%)

Table 7 Positions held in primary and secondary schools (N = 939)

The majority of teachers in the sample reported that they are qualified at the 3 or 4 year trained level. Some have undertaken postgraduate study and some identified themselves as 2 year trained. Details are given in Table 8.

School level	2 years	3 years	4 years	> 4 years
Primary	53 (9%)	245 (41%)	280 (46%)	24 (4%)
Secondary	3 (1%)	21 (6%)	281 (84%)	29 (9%)

Table 8 Years of teacher education (N = 939)

Analysis of variance in beliefs data

The data were tested for significant levels of difference on the two confirmed factors (transmission and child-centredness) across the demographic variables. In this paper, comparison of beliefs data for the variables of school sector, school location, school level and gender of respondents is reported.

Sector: Catholic school respondents (mean = 0.3219) scored significantly higher ($t=-2.69$, $p<.01$) on the child-centredness factor than respondents from government schools (mean = 0.1194) but there was no significant difference between the two sectors on the transmission factor.

Location: North coast school respondents (mean = 0.2077) were more likely to support statements relating to child-centredness ($t=-2.10$, $p<.05$) than respondents from south western Sydney schools (mean = 0.0834) but there was no significant difference between the two locations on the transmission factor.

Level: Primary school teachers who identified themselves as "mainly K-2" (mean = 0.2047) or "mainly 3-6" (mean = 0.1695) or "mainly 5-6" (mean = 0.0714) reported significantly higher agreement with the child-centredness statements ($F=13.6738$, $p<.0001$) than did secondary mathematics teachers (mean = -0.2615). However, there were no significant differences on child-centredness amongst these three groups of primary teachers.

On the transmission factor, no significant differences were found between the secondary mathematics teachers, "mainly K-2", mainly 3-4" and "mainly 5-6" teachers. However, although not significant, there was a discernible trend towards secondary teachers scoring higher on this factor than primary teachers.

Gender: Female teachers (mean = 0.1006) scored significantly higher ($t=4.42$, $p<.001$) on the child-centredness factor than did male teachers (mean = -0.1667). Male teachers (mean = 0.0691) scored significantly higher ($t=-2.31$, $p<.05$) on the transmission factor than did female teachers (mean = -0.0629).

Discussion

Justification has been given through the use of confirmatory factor analysis for the existence of two factors - transmission and child-centredness - to be used in categorising teachers' espoused beliefs about mathematics, mathematics learning and mathematics teaching. The survey used in this study is one means by which data can be gathered to profile teachers on these two factors.

The survey findings give rise to a number of questions which need further investigation. Some possible answers to these questions are given below, based on the authors' experience and reading. The authors intend to test these through focus group interviews during 1998.

Why do Catholic school teachers score higher on child-centredness than government school teachers? Catholic schools emphasise their pastoral care role and concern for the student as an individual. Thus, Catholic school teachers may have a more focussed concern for the child in all their teaching, including mathematics, than government school teachers.

Why is there a higher level of child-centredness among north coast teachers than those teaching in south western Sydney? Teachers in south western Sydney may be more concerned with management issues than north coast teachers because of the perceived classroom pressures associated with this area of Sydney and the relatively less-experienced group of teachers in this area.

Another possible reason arises from the relative socio-economic levels of each of the areas. There is ample evidence that socio-economic status is highly correlated with students' achievement. Haberman (1994) suggests that the local social context leads to a preference for the maintenance of the status quo rather than change. The status quo in many urban schools in low socio-economic areas is what Haberman (1994, p.17) refers to as "the pedagogy of poverty". Hatton (1994) describes this pedagogy as "a highly directive style of teaching based on rote learning of the basics, formulated without reference to adequate pedagogic or social theory and typically implemented in tough urban schools" (p.15). Haberman (1994) suggests that "[T]he pedagogy of poverty requires that teachers who begin their careers intending to be helpers, models, guides, stimulators, and caring sources of encouragement transform themselves into directive authoritarians in order to function in urban schools" (p.19).

Why do primary teachers score higher on child-centredness than secondary mathematics teachers? The teacher education undertaken by primary teachers normally differs in focus to that of secondary mathematics teachers. Primary teacher education programs focus on children's learning more holistically than secondary mathematics teacher education programs with their main focus on content.

Primary school teachers normally interact with their class all day, they are able to get to know their children on an individual basis and they are not constrained by timetable matters as much as secondary mathematics teachers. Secondary teachers may well work under greater pressures of time and content coverage and certainly under greater examination pressures, although recent changes to basic skills testing have diminished this difference. Compared to primary teachers, it may be that secondary mathematics teachers just do not have the time to be as child-centred in their teaching.

Why is there no significant difference on child-centredness amongst the responses of the three categories of primary school teachers? In primary schools, there is usually a common structure across the seven years K-6, there is a common

mathematics syllabus and there have been substantial efforts to create K-6 schools. Further, the K-6 mathematics syllabus is used extensively across primary schools and emphasises child-centred approaches to the learning and teaching of mathematics. (NSW Department of Education, 1989, pp 4-5).

Why do female teachers score significantly higher on child-centredness than male teachers? One possible reason is that women are perceived to be more anxious towards mathematics than men (Forgasz & Leder, 1996). Due to their personal appreciation of this anxiety, female teachers may be more child-centred in their teaching because they are more aware of the need to address the affective concerns of children. There are more female teachers in this sample teaching in the lower years of the primary school where the teaching/learning strategies used are more child centred than those in the later years of schooling.

Why do male teachers score significantly higher on transmission than female teachers? Male teachers may well base their teaching on their past experiences in classes where power relationships and the delivery of information -transmission of information- was the preferred mode of delivery by their teachers.

Why are there no significant differences across school level, sector or location on the transmission factor? It may be that teachers who tend towards a transmission approach are more satisfied with it because it has brought success in the past to both them and their students. They believe there is little reason for changing.

Conclusion

The survey used in this study is a valid instrument for the investigation of teacher beliefs about mathematics, mathematics learning and mathematics teaching. It could be used to help teachers, both pre-service and in-service, to know their own teaching styles.

The introduction of social constructs such as the 'pedagogy of poverty' require mathematics educators to question the relevance of particular approaches to mathematics learning and teaching which have been developed in particular social contexts. A variety of teaching approaches may be needed to meet the requirements of the diverse group of students in our schools. The significant differences found in this study point to the need for further careful analysis of the learning and teaching of mathematics in classrooms situated in differing social contexts.

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