INFLUENCES ON THE CHANGING ROLE OF THE MATHEMATICS TEACHER

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This case study research investigated changing teacher roles associated with two teachers' use of innovative mathematics materials at grade six level. Using daily participant observation and interviews with the teachers and the project staff member responsible for providing in-school support, a picture emerged of changing teacher roles and of those factors influencing the process of change. One teacher demonstrated little change in either espoused beliefs or observed practice over the course of the study. The second teacher demonstrated increasing comfort with posing non-routine problems to students and allowing them to struggle together, without suggesting procedures by which the problems could be solved. He also increasingly provided structured opportunities for student reflection upon activities and learning. Major influences on this teacher's professional growth appeared to be the provision of the innovative materials and the daily opportunity to reflect on classroom events in conversations and interviews with the researcher.

THE TEACHER'S ROLE IN A REFORMED CLASSROOM

With increasing interest in curriculum and professional development programs designed to encourage mathematics teachers to reconceptualize their roles, two needs have emerged. First, there is a need for clear descriptions of the role of teachers in such "reformed" classrooms. Second, there is a need for detailed descriptions of the process of teacher change, with an emphasis on those factors which are seen to exert an influence on that process. The major question addressed by this study was the following:

> What are the factors likely to influence the process of changing teacher roles as they implement innovative mathematics curricula?

A six-component categorization of the teacher's role was developed, drawing on seven projects or studies that had many features in common with the vision of mathematics education reform (Cobb, Wood, & Yackel, 1990; de Lange, van Reeuwijk, Burrill, & Romberg, in press; Fennema, Carpenter, & Peterson, 1989; Lampert, 1988a; Middle Grades Mathematics Project 1988; Schoenfeld, 1987; Stephens & Romberg, 1985). This categorization appears in Table 1, and provided a "conceptual framework" for the study (Eisenhart, 1991). There is considerable evidence in the research literature that beliefs and practice are dialectically related, and the structure of the table reflects this relationship. It is also recognized that teachers can espouse certain beliefs not in harmony with observed practice (Thompson, 1992). It is not claimed that the six components are an exhaustive list, and not all of the studies placed equal emphasis on each aspect. However, the

Table 1
Components of the Role of the Teacher in a Reformed Classroom and Related Beliefs about the Teaching and Learning of Mathematics

Components of the Role (what the teacher does)	**Related Beliefs About the Teaching and Learning of Mathematics**
1. The use of non-routine problems as the starting-point and focus of instruction, without the provision of procedures for their solution	Students can solve non-routine problems without first being taught a procedure

2. The adaptation of materials and instruction according to local contexts and the teacher's knowledge of students' interests and needs	Mathematics needs to be studied in living contexts which are meaningful and relevant to students, including their languages, cultures, and everyday lives
3. The use of a variety of classroom organizational styles (individual, small-group, whole-class)	Differences in mathematical tasks and preferred learning styles of individuals demand variety in classroom organization
4. The development of a "mathematical discourse community," with the teacher as "fellow player" who values and builds upon students' solutions and methods	An atmosphere of conjecture and justification of mathematical ideas enhances learning Teachers should be open about their own struggles with mathematical problems Students' solutions and methods provide the basis of discussion of problems
5. The identification and focus on the big ideas of mathematics	Important mathematical ideas are not confined to specific procedures in isolated content areas, but rather mathematics is seen as an integrated whole, in which the processes of problem solving, reasoning, and communication are central
6. The use of informal assessment methods to inform instructional decisions	Observing and listening to students provides a "window" into their thinking which can be used to plan further instruction

components did provide a useful framework for studying the role of the teacher in this study, and in particular the changes in this role. One consequence of this study was the augmentation of this framework.

THE FOCUS OF THIS STUDY

This was a study of teacher change. A case study approach was used in studying two grade six mathematics teachers, Ms Bartlett and Mr Martin, from a school in a midwestern United States town. The teachers had taught at the school for around 20 years, most of this time at grade six level. During the course of the study, the teachers participated in a professional development program, part of which involved teaching a six-week unit of work consisting of non-routine problems built around the theme of the discovery of a bone belonging to a "mystery person". The unit of work used in the study was one from *Maths in Context* , a curriculum development project based at the University of Wisconsin. The professional development program was designed by project staff to reflect principles from the literature identified as important in facilitating teacher's professional growth (see Clarke, in press). The teachers were supported in the process of teaching the unit by regular visits from a project staff member, Ms Saunders, a graduate student.

Participant observation and interviews with the teachers were used to build a picture of their roles, their perceptions of these roles, and the process of change in these. As well as observing both teachers on 36 occasions, I also observed their participation in team meetings and inservice sessions, and interviewed them six times each. The decision to work with two teachers provided the opportunity to document the ways in which different individuals perceive and respond to very similar opportunities for, and impediments to professional growth. The two teachers were part of a team of four who worked closely together in planning their curriculum.

In the same way that reform documents describe student learners as active constructors of mathematical meaning in a social context, in this study teachers too were viewed as learners who actively create knowledge through experience, and through reflection on that experience, in large part through communication with other teachers (Gunstone & Northfield, 1988).

While the study attempted to answer the main research question stated on page 1, the sub-questions relevant to the context in which this study occurred are the following:

1. In using a unit of work based largely on non-routine problems situated in real contexts, in what ways does the role of the teacher change?
2. What factors influence the process by which the identified changes occur, and what is the nature of these influences?

Data were collected inside and outside classrooms in several phases over a period of seven months. These phases corresponded to a short period before teachers began the first *Maths in Context* unit, an intensive period of work during the teaching of the first unit, and further (but less intense) data collection during the time between the teaching of the first and second *Maths in Context* unit (around four weeks). Analysis of the data enabled me to describe the process of teachers changing their role, and the varying influences of a range of factors on that process. This analysis was greatly enhanced by the use of a software package, *Hyperqual* (Padilla, 1990), which enabled the coding and sorting of interview and observational data.

THE CHANGING ROLE: THE TWO TEACHERS

Ms Bartlett

The teaching of the innovative curriculum unit proved to be a fairly stressful experience for Ms Bartlett. There were many apparent reasons for this, some related to her teaching role, others of a more personal nature. For the six weeks during which the unit was taught, Ms Bartlett had a maximum of 45 minutes for mathematics, and for four of these weeks Ms Bartlett had to leave the classroom with her students in order to assist them with computer studies. She found this scheduling arrangment most inconvenient, and also found assisting with the computer class a difficult challenge (Field notes, 9/9/92).

The small growth that I observed (and my observations were confirmed in conversations with Ms Bartlett) was not so much in Ms Bartlett's *role* in the classroom, but rather in her stated commitment to certain *beliefs* associated with that role. Ms Bartlett identified many areas in which she believed she had changed in the two or three years prior to the study (including problem solving and the use of cooperative group work), but the experience of teaching the unit and the related staff development activities appeared to lead to little change in the short-term in Ms Bartlett's classroom practice.

Mr Martin

Although Mr Martin saw himself as having changed his teaching gradually over the previous five years (like Ms Bartlett, he mentioned more problem solving and group work as major changes in his teaching prior to the study), the teaching of the measurement unit, in Mr Martin's terms, provided "a better vehicle" than he had ever had before. He enjoyed the unit, was excited by what his students had done with it, and was already planning how he would teach it the following year.

In the time during which I observed Mr Martin *prior* to his involvement in the *Maths in Context* project, he had placed considerable emphasis on the importance of making the tasks that he presented as straightforward for students as possible. This was usually achieved by anticipating any difficulties students were likely to have, and either removing them or offering a procedure by which they could be overcome. This action on his part was later to be described by him as "short-circuiting" students' thinking.

The major area of professional growth that I observed over the course of the study was in Mr Martin's increasing willingness to "step back" and let students struggle with problems, resisting the pressure to curtail mathematical exploration by the provision of his method of solution. For Mr Martin, then, this component of the teacher's role became "to tell or not to tell." This area of growth was confirmed by Mr Martin during numerous brief conversations and interviews. He referred often to the constant desire that he felt to help students to avoid difficulties by laying out a path for them, a desire that he increasingly resisted over the course of the measurement unit as he saw the power of student solutions, given minimal guidance:

> I am aware of that now, more so than before of letting kids struggle with those decisions themselves rather than having me lay it out for them. I think what happens is teachers, at least I do, I have part of my own feeling of success or failure related to whether I think kids are successful. So maybe I

> do too much to insure a certain sort of shallow success. If I have to hand it to them perhaps it's really not success, but it could be interpreted as that anyway. (Interview, Mr Martin, 10/9/92)

During conversations with Mr Martin, he identified inconsistencies between his beliefs about teaching and learning and his classroom practice, particularly in the area of "basic skills" and assessment techniques. These inconsistencies did not appear to be resolved during the course of the study, but it appeared likely that they would continue to be addressed by Mr Martin over time, given appropriate opportunities to discuss them.

In considering classroom practice as providing insight into a teacher's beliefs about how mathematics should be taught (allowing, of course, for the kinds of inconsistencies discussed by Thompson, 1992), the context in which Mr Martin was teaching seemed to determine his approach. When using the measurement unit, his approach had many of the features of a classroom built around social constructivist learning principles (Cobb, Wood, and Yackel, 1990), and therefore in harmony with the entries in Table 1. However, when he was using other curriculum materials, the focus tended to be on introducing procedures which students were then expected to follow. The implications of this contrast will be discussed later.

A seventh component of the teacher's role--the facilitation of student reflection on activity and learning. In the time prior to and following the teaching of the measurement unit, Mr Martin seemed to spend only a small amount of time discussing the purpose of the day's mathematical activity. However, during the course of the measurement unit, Mr Martin increasingly took time to encourage students to reflect on their recent experiences. Questions such as "why did I get you to do that activity today?", "What were you supposed to learn from creating that table?", and "Why would someone want to know their surface area anyway?" became more and more common as the unit proceeded.

We discussed the need that Mr Martin saw for the pace of classroom activity to slow down to give students a chance to think about what they had been doing and what they had learned:

> I'm conscious of what went on the day before, or the week before even, and I attempt to bring that in because I get the feeling in my past . . . there can be this kind of busy stream of consciousness sort of phenomena, too. If I'm a kid and I'm sitting out there, it would seem to me like all these facts and activities are being run past me on 78 when I'm a $33\frac{1}{3}$ guy.
>
> (Interview, Mr Martin, 9/17/92)

Mr Martin used terms like "treadmill" and "roller coaster" to describe the frantic pace at which students move from content area to content area during the school day, and he stressed the importance that he attached to slowing down the pace. Mr Martin's emphasis during the reflection time in mathematics was related to his clear understanding of the big mathematical ideas of the measurement unit. He would invite students to suggest the mathematical purpose of the lesson and the specific activities within it, and help students to form connections with other mathematical content and between the content and their experiences. However, his attempts to allow for this reflection time were evident only during the measurement unit, and not particularly at other times.

For most of the measurement unit, Mr Martin had the flexibility to extend the mathematics lesson by up to 30 minutes. This extra time was used to either enable students to finish their group measuring or writing tasks, or to provide a kind of "debriefing" session on what had transpired on that day. This flexibility of time proved to be a major influence on his professional growth, as it provided further opportunity for him to see the quality of student work on the assigned tasks.

FACTORS THAT INFLUENCED THE PROCESS OF CHANGING ROLES

1. The reform movement in general. Documents such as the *NCTM Standards* paint a picture of the "reformed classroom." Such documents and the general climate of reform can provide impetus to changing teacher roles. *The Standards* were seen by teachers as validating "gut feelings" about teaching.

2. The principal and school community. The principal and school community can encourage innovative programs in schools by financial, affective, and other forms of support. The principal made innovation in mathematics a school priority, and his support was reflected in financial commitment to resources and inservice participation, the hiring of new staff, and by regular visits to classrooms.

3. Internal support personnel. The school mathematics coordinator and other internal support staff can contribute to the professional growth of teachers in a variety of ways. In this study, the mathematics coordinator saw her role as connecting interested teachers with appropriate resources and personnel, and working with teachers in classrooms. Such support varied considerably from teacher to teacher.

4. The spirit of collegiality, collaboration, and experimentation. There is a strong emphasis in the literature on the value to the professional growth of teachers of an atmosphere in the school. The school featured in this study was proud of its involvement in innovative practice in mathematics, and most teachers were comfortable with the expectation that they be constantly trying new approaches, and sharing both planning and reflection with their colleagues.

5. The grade level team of teachers. Teachers at a particular grade level can benefit from joint planning, and can support each other in the use of innovative materials or teaching approaches. The four grade six teachers in this study worked closely together in planning and teaching.

6. Innovative curriculum materials. As teachers and students use innovative curriculum materials, teachers may experience many positive benefits, e.g., student thinking may be exhibited in unanticipated ways, or students and teachers may feel more positive about the subject area. Both teachers were impressed with how the students reacted to the curriculum materials and with the quality of students' work. One teacher took a far less directive role as he observed the quality of unaided student thinking.

7. The inservice program. Inservice programs have the potential to give teachers access to knowledge from research and from other practitioners, and provide opportunities for sharing experiences with teachers engaged in similar struggles. However, the two teachers claimed that they received little benefit from their participation in the four inservice sessions, largely because other participants were perceived by the two teachers to be "at a stage they were at" two or three years previously.

8. External support personnel. The research literature is clear on the importance of support in "the actual process of use," whether by external or internal personnel. This support may be cognitive or affective. The project support person had 16 staff with which to work, and was consequently able to spend only a small time with the two study teachers. The support was largely *affective.*

9. The researcher as audience and critical friend. The role of critical friend can theoretically be taken by any of a number of people involved in a new initiative (e.g., mathematics coordinator, external project staff, other teachers). The presence of the researcher and the discussions about classroom events necessary for data collection (both formal and informal), provided a vehicle for reflection by the teachers.

10. Outcomes valued by the teacher. Student learning has been shown by other research to have an impact on teachers' professional growth. However, other outcomes can be valued by the teacher, such as quality student work with innovative materials and positive student reactions. Such outcomes have the potential to influence teachers' commitment to innovative approaches.

11. Day-to-day conditions under which teachers work. Teaching conditions can prove a major impediment to the professional growth of teachers. Although the teachers had many positive working conditions (e.g., considerable joint planning time and within-classroom assistance for students with learning disabilities), the grade six teaching schedule was "packed" for one of the teachers.

12. Teacher knowledge. The depth of a teacher's content knowledge and the way it is organized has been shown to affect the way in which it is presented to students. One teacher perceived herself to be lacking mathematical knowledge and had difficulty in presenting the tasks for students in a way that might have fostered such connections. The unit used by the teachers had 13 different mathematical topics within it, and this added to the difficulty. The other teacher saw the connections between these different topics, and took considerable additional time to encourage students to reflect on their experiences and to start to make appropriate connections.

SOME ASPECTS WORTHY OF FURTHER CONSIDERATION

1. In terms of content knowledge, the logical question that arises from this study is the following: "How can a teacher who lacks a "network of big ideas and the relationship among those ideas and between ideas, facts, and procedures" (Lampert, 1988b, pp. 163-164), develop these things?
2. In projects focusing on reformed notions of mathematical teaching and learning, greater energy needs to be directed to the selection and preparation of support staff, whether this preparation occurs in the context of mathematics education or in more general settings. If this means that less effort is given to preparing staff to lead inservice work, then this study (coupled with the existing research on the process of change) would indicate that the pay-off may be worth it.
3. Thompson (1984, 1992) observed that the extent to which experienced teachers' beliefs about the teaching and learning of mathematics are consistent with their classroom practice depends largely on their tendency to reflect on their actions. It would seem that the role that the researcher played in facilitating reflection could conceivably have been carried out by the mathematics coordinator or by another teacher, assuming that time commitments permit, appropriate preparations are made, and the focus aspects of changing teacher role are mutually established by the participants.

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