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Case studies of changes of beliefs of two in-service primary school teachers

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Within the mathematics teacher education program, a variety of teaching strategies and theories are discussed with the aim of changing the student teachers views about mathematics and its teaching. This study was conducted with two in-service primary school teachers as they progressed through a 4-year degree programme. The purpose of the study was to identify how their views about mathematics and its teaching evolve during the three years leading to their internship assignment. Furthermore, the study was intended to document whether changes in teachers' beliefs accompanied changes in their classroom practices and more importantly, what influenced the teachers to commit to change. Data were collected through class observations, interviews, review of the lesson notes, field notes, and internship books. The results reveal that one participant modified some of his beliefs about mathematics teaching. The changes identified indicated a shift in perception of the teacher as an authority to that of a teacher concerned with initiating a learner-centered process, and using students' knowledge and errors as starting points. The other participant's perceptions of the teacher remained to be of authority; giving explanations, and demonstrations followed by students doing assigned problems. The results, however, reveal that the two participants' beliefs on how to learn mathematics changed from emphasizing algorithms to understanding concepts.

Introduction

Studies have shown the importance of investigating teachers' beliefs due to their close relationship to instructional practices (Thompson, 1992; Fernandes, 1995). Studies of pre-service teachers' beliefs conducted within and across disciplines suggest that as students enter teacher education programmes, they do possess established although incomplete conceptions of teaching (Mertz & McNeely, 1991). Mertz and McNeely further argue that such perceptions are often rooted in school experiences, including memories of past and pre-service teaching experiences.

Bullough (1989) and Heck and Williams (1985) report that during the first year of teaching, beginning teachers are concerned with a multitude of things. They worry about classroom management, establishment of a professional identity, and carrying out administrative duties. Aside from the notion that interesting instruction makes behavior management no longer a concern, many teachers see the roles of supervisor, instructor, and friend as being disparate and serving different ends. Becoming a facilitator and helping students develop appropriate dispositions toward mathematics are possible only in so far as they are consistent with the teacher's beliefs about him or herself as a teacher and as a mathematics teacher.

Studies have shown that the teachers' conceptions and beliefs are deeply rooted in themselves, they are constant and can hardly change (Thompson, 1992; Arsac, Balacheff & Mante, 1992; Stigler & Perry, 1988). In addition, Munby (1982) reports that beliefs of veteran teachers are well grounded and extremely resistant to change. Cronin-Jones and Shaw (1992), however, suggest that beliefs of pre-service and novice teachers are amenable to change as a result of instruction and/or experience.

Grouws and Schultz (1996) argue that there was little information available about the overall design features of in-service education programmes, which produce changes in teachers' beliefs and classroom practices. Teacher training programmes show that student teachers are generally offered little opportunity to change the views they formed of mathematics and how it is taught during their years of pre-university schooling (Kagan, 1992; Bednarz, Gattuso & Mary, 1996). Studies cited by Bednarz, Gattuso and Mary (1996) further report that in their own classroom practices and teaching strategies, student teachers consistently adhere to their previously acquired views.

Becker and Pence (1996) however, report having identified several aspects of the mathematics teacher development programme that were positively related to teacher change. They identified the need for support network as teachers tried to implement change, the opportunity for teachers to engage in conversations about mathematics teaching and learning, and the length of time in staff development as some of the positive aspects of the programme. In addition, Valero and Gomez (1996) report of a teacher who modified her behavior in class, although could not change completely her belief system. They further found that being involved in the experience, the teacher began a questioning process that could lead to real eventual change in her belief system.

Knowles (1992), however, argues that subsequent changes induced by teacher education programmes, regarding the ways in which pre-service teachers thought about teaching and education seem to occur to a minimal degree over the duration of the pre-service years. In addition, Nemser (1983) observed that the impact of the teaching experiences student teachers gather in primary and secondary schools shape their views on how one should teach and how children learn. These views then become so strong that a preservice programme has hardly any impact. Even if student teachers are confronted during their teacher training period with a constructivist approach, transfer of theory to practice is poor (Resnick, 1983).

According to Lampert (1988) and Guyton and McIntyre (1990) teachers generally consider field experiences as the most valuable part of their formal teacher education programme. Brown and Borko (1992), however, contend that field experience may have negative effect on the development of research-based and reflective teaching practices. Also Zoest and Darby (1996) report that when teacher preparation programmes respond more to calls for reform than school classroom, preservice teachers' field experiences are inconsistent with the expectations in their teacher education course work. In addition, Nieuwoudt (1998) report that the current conventional preservice mathematics and methods practices are reinforcing rather than curbing the negative impact of transmission school mathematics teaching on people's fundamental school mathematics related beliefs. This raises the question of how to manifest change in ways teachers learn and teach mathematics, and more importantly, whether changes in a teacher's behavior can come about due to different exposures. Attempts, however, are made to find ways for teacher education, focus on changing student teachers' conceptions and beliefs (Bouffi, 1994; Fernandes, 1995).

Theoretical framework

Beliefs and knowledge

Schoenfeld (1994) defines beliefs as an individual's understanding and feelings that shape the way the individual conceptualizes and engages in mathematics behavior; and Pehkonen (1997) explains that beliefs constitute subjective knowledge of mathematics. Ernest (1989) however, suggests that knowledge is the cognitive outcome of thought and belief is the affective outcome, but he acknowledges that beliefs also possess a slender but significant cognitive outcome. Grossman, Wilson, and Shulman (1989) further argue that knowledge is justified as

true through objective proof or consensus of informed opinion, but such standards hardly apply to beliefs. In contrast, beliefs are often held or justified for reasons that are characterized by lack of agreement over how they can be judged or evaluated. As opposed to knowledge, beliefs carry the connotation of disputability. The distinguishing characteristic of knowledge is the agreement about procedures for evaluating and judging its validity. Feyeraband (1975) and Kuhn (1970) argue that what have been claimed as knowledge at one time may in light of new theories, be judged as beliefs. On the other hand, a once held belief may be accepted as knowledge in light of new supporting theories.

An analysis of beliefs

Belief systems are structured set of views, conceptions, values held by a teacher with respect to the elements composing his or her teaching practices (Valero & Gomez, 1996). Malone (1996) reports that some characteristics of teachers' beliefs are held within organized systems of mind that vary in how strongly they are held. He argues that while connections between teachers' beliefs about mathematics and their classroom practices can be made, beliefs may be influenced by other factors in the context of the classroom. Teachers' beliefs might seem to contradict classroom practices (Becker & Pence, 1996; Cooney, 1985; Brown, 1985, Shaw, 1989). For example, a teacher might believe that technology should be used to teach mathematics and thus the students should be allowed to use calculators (Cooney, Shealy & Arvold, 1998). The psychological strength of the belief may not be very strong, so when faced with classroom constraints to implementation, the commitment to use the calculators diminishes.

Green (1971) argues that the role of evidence is critical in modifying an individual's beliefs. He distinguishes between beliefs that are nonevidentially held from those that are evidentially held. He regards beliefs that are held without regard to evidence or contrary to evidence as non-evidential. For example, a teacher may believe that she/he should make use of co-operative teaching approach and emphasize interaction among students but she/he may have no experience with co-operative teaching in mathematics but still believe that as an alternative to individual classroom co-operative teaching is preferred. Although she/he may have little success with this pedagogical approach, the importance she/he attaches to it may render it non-falsifiable. Introducing evidence or reasons cannot modify these types of beliefs. These beliefs cannot be changed by rational criticism. He, however, argues that beliefs that are held on the basis of evidence can be modified in light of evidence or reasons. Green refers to these types of beliefs as beliefs held evidentially. These beliefs can be changed by rationally criticizing and can be modified in light of new evidence. These three characteristics of beliefs — evidentially, non-evidentially and disputability helped to provide a framework for this study and to interpret its results.

The research literature on mathematics teachers' beliefs indicates that teachers' approaches to mathematics teaching depends mostly on their systems of beliefs, in particular on their conceptions of the nature and meaning of mathematics and on their mental models of teaching and learning mathematics (Ernest, 1988). A model by Ernest (1989) was used to specify the beliefs under investigation. Of the four elements of teacher's beliefs stipulated by Ernest, I used a) teacher's conceptions of mathematics, b) model for teaching mathematics, and c) for learning mathematics. More attention was given to teachers' models for teaching mathematics as described by Ernest as:

> their conception of the type and range of teaching actions and classroom activities contributing to their personal approaches to the teaching of mathematics. It includes mental imagery of prototypical classroom teaching and learning activities, as well as the principles underlying teaching orientations (Ernest, 1989:22).

In the light of this theoretical analysis I studied two in-service primary school teachers as they progressed through a 4-year Bachelor of Education degree (BEd) (Primary) teacher education programme. I focused mainly on what they believed and how those beliefs influence their teaching of mathematics during their internship exercise. I considered how each of the participant's beliefs allow for possible changes in beliefs, noting whether the beliefs are held evidentially or non-evidentially, and the extent to which those changes stem from activities encounted during the teacher education programme.

Background

When the mathematics reform movement of the 1980s was developed, the different teaching methods were developed on the idea that open-ended problems that encourage students to choose different methods, combine them, and discuss them with their peers would provide productive learning experiences (Boaler, 2002). Such teaching methods, however, have not been well received by all parties (Becker & Jacob, 2000). Some of the objectives came from mathematicians and others who gained extensive understanding of mathematics through more traditional routes (Klein, 2001). The recent objectives came from those whose focus is on equity who expressed concerns that reform-oriented approaches to mathematics may not enhance the achievement of all students as reformers initially hoped and claimed (Lubienski, 2000).

Despite these objections, mathematics education reforms have been suggested and extensive changes in the teaching of mathematics have been advocated by organizations such as the National Council for Teachers of Mathematics and the Australian Education Council (Day, 1996). Classroom teachers are expected to be agents of these changes in teaching and learning mathematics in schools. One of the most significant issues in the literature of teacher education is relevant to the conceptions and beliefs that mathematics teachers have about mathematics and education process (Thompson, 1992). The procedure-oriented mathematics that most elementary school teachers experienced as students has left many feeling inadequate and often fearful of or disinterested in the subject (Simon, 1993). An examination of teachers' beliefs is of significance as mathematics teachers everywhere having learned mathematics in environments where they were passive receivers of decontextualised facts and procedures passed down from their own teachers, are now asked to move into new territory involving student-centered activity (Malone, 1996; Day, 1996).

The interaction between teachers and their training experiences often results in a process of conceptualizing the issues presented during their teacher training process (Arsac et al, 1992). Bednarz *et al.* (1996) argue that if teacher training programmes are to effectively counterbalance student teachers' socialization experiences, they should take into account the student teachers' previously formed views about mathematics and how it is taught and learned. It is possible that beliefs which are less central (Rokeach, 1968), and those held with less conviction (Thompson, 1992), can be open to change or manipulation by outside influence such as the teacher and new experiences.

The task of modifying preservice teachers' conceptions of mathematics remains a major problem in mathematics teacher education (Thompson, 1992). Cooney and Shealy (1997) argue that "what teachers believe and how their beliefs are structured provide us a means of conceptualizing teacher education in ways that promote change in something other than a random manner" (p.106). In order to work on the problem and design successful intervention techniques for use in both mathematics content and mathematics methods courses, it is essential that we are knowledgeable of beliefs about mathematics and mathematics teaching that future teachers bring to these courses.

University of Botswana programme

The in-service teacher education programme at the University of Botswana focuses on upgrading the primary school teachers' subject content knowledge and pedagogical content knowledge. In addition, the candidates are required to take part in a 3-months internship in the colleges of primary education. In the first year of the BEd (Primary) programme, the in-service teachers do seven courses, mathematics included. At the end of the first year, the in-service teachers choose areas of specialization.

The main objective of the mathematics methods course is to expose the in-service teachers to approaches to mathematics teaching that are different from the ones they have experienced and practiced previously. It also introduces them to teaching approaches that involve explanation, discussion, and negotiation within the classroom. The methods course therefore, focuses on developing insights into students and their difficulties in learning mathematics. It also focuses on theories of teaching and learning mathematics. In addition, it focuses on the teaching of innovations such as assessment in mathematics education, activity-based teaching and learner-centered teaching approaches. The content course, on the other hand, focuses on mathematics topics such as number theory, algebra, functions, geometric series, matrices, and co-ordinate geometry.

Although after graduating from the university programme, the participants will return to the primary schools and teach mathematics and the rest of the school subjects, the internship at colleges of primary education is to prepare them for leadership roles in the mathematics in-service workshops at Teachers Centres. They will also be helping their colleagues in the primary schools in the mathematics teaching. Some of them are later Staff Development Fellows in the colleges of primary education.

Purpose of the study

This study used a naturalistic paradigm (Lincoln & Guba, 1985) in which the researcher was a participant observer. The focus of this study was to develop an understanding of how the initial views and perceptions held by the two in-service primary school teachers about mathematics and mathematics teaching evolved as they progressed through their BEd programme (Primary) and participated in the internship. The study compared the perceptions that emerged as the two teachers began programme participation with the views that evolved after 3 years in the programme.

This study provides teacher educators, researchers, and classroom teachers with information about beliefs of two in-service primary school teachers as they progressed through the in-service teacher education programme. The study is descriptive in nature in that it documents the evolution of the in-service primary school teachers' beliefs in a programme that explicitly attempts to upgrade the primary teachers' mathematics content and improve pedagogical content knowledge, and challenges existing beliefs about mathematics and its teaching.

Methodology

The method of research for this study falls within the boundaries of qualitative inquiry (Erickson, 1986). It shared many of the characteristics of the ethnographic traditions. The three ethnographic methods (interviewing, participant observation, and researcher introspection) formed the research methodology of this study. These three research methods contribute to a more complete picture of the scene of interest (Eisenhart, 1988). The methodology for this study evolved from an interest in finding a holistic method of investigating changes in beliefs of the two in-service primary school teachers as they progressed through a four-year degree programme at the University of Botswana.

The selection of the methodology was designed to ensure participation of those teachers who exhibited uncertain views towards mathematics and its teaching during their Primary Teachers Certificate (PTC) programme. The participants were informed that the study was about their mathematics learning and teaching styles. They were, however, not informed that the study was about how their beliefs are affected by the programme. This was to ensure that the participants do not fake any changes in their mathematics learning and teaching styles. The pseudonyms Khento (female) and Zozo (male) were used for the two in-service teachers.

Research setting

The research setting was a primary in-service teacher education programme in the University of Botswana. The two participants were majoring in mathematics education. The two in-service teachers are qualified and experienced primary school teachers. They have a 2-year PTC. They each taught for three years in the primary schools after completing their PTC programme. They came to the University of Botswana for a 4-year Bachelor of Education Degree (BEd) (Primary) programme. The BEd entry requirements are a Cambridge Overseas School Certificate (COSC), a PTC, and a two-year teaching experience in primary schools. In addition, candidates are required to score 70% on entry test set by the University of Botswana.

The selection of the two participants from the cohort group was based on the initial analysis of their PTC mathematics examination scores, their PTC teaching practice grades, the University of Botswana mathematics entry test scores, and the scores from their first mathematics test. They had the highest PTC mathematics tests scores, but they exhibited uncertainty about their mathematics learning. Their entry tests scores ranged from 75%-85%. In the first mathematics test, Khento scored 70% and Zozo scored 60%.

Data collection

Data were collected through observations of the participants' mathematics learning, and interviews about their mathematics learning and teaching. Data began by reviewing the videotapes of the student teachers PTC internship and their PTC mathematics examination scripts. This was to set a baseline for investigating any changes in the participants' beliefs about mathematics learning and its teaching. Other data collection started during the first year 1996/97 of the participants' BEd (Primary) programme.

The beliefs of the two in-service primary school teachers were identified as cases for the study. Each of the in-service teachers was interviewed during the first year 1996/97 and observed teaching at the end of third year 1998/99. The interviews were in three phases. The first phase of interviews was in two stages. The first stage was in the first semester of the first year 1996/97 of the programme and the second stage was at the end of the year. The second phase of interviews had only one stage. The interviews were in second semester of the second year 1997/98 of the programme. The final phase of the interviews was in third year 1998/99 of the programme and was in two stages. The first stage was in first semester and the second stage was during and after the internship exercise.

The interviews were structured and I used mostly open-ended questions. The framework of each interview was based on 3 areas: (1) mathematics content (2) students' beliefs about the nature of mathematics, and (3) mathematics learning and teaching. Each interview lasted between 50 and 60 minutes. Interviews were audio taped.

In the initial phase of interviews, conducted at the beginning of the programme, I probed the participants' perceptions of their mathematical background. I also requested them to reflect on their experiences as students in mathematics education at the university level. In the second phase of interviews, I sought to understand how the experience of first and second years in the BEd programme had affected their views about mathematics. To supplement these data, I reviewed documentation pertaining to the students' progress.

From June-August of the third year of the programme, in-service teachers go on a 3 months internship in the colleges of primary education. The final phase of interviews took place before and during the internship exercise. The first stage of the final phase of the interviews took place prior to the teaching exercise. It took place during the observational period by the participants. I wanted them to discuss their perceptions of their college cooperating mathematics lecturers' instructions as well as the college students' views about mathematics and mathematics learning. The second stage of this phase took place during the teaching practice experiences. It was based on classroom teaching observations. The classroom observation focused on the participants' mathematics instructions (e.g., their explanations, demonstrations, and assignments of student tasks). During the class observations, I wrote brief and detailed notes of particular student

activities. In these notes, I included my reactions to what had occurred. Following the observations, I asked them to focus on their own teaching experiences. I asked the participants to discuss their successful and unsuccessful lessons. These data were supplemented by reviewing their written lesson plans, and classroom handouts, and the internship book which they had to complete towards the end of the internship exercise. The internship book contains a detailed account of the student teachers' teaching experiences.

Data analysis

The analysis of data was structured according to Day (1996) and Malone (1996) espoused. Coding (Strauss & Corbin, 1990) included analysis of the pre-and post-instruction observation interviews and was designed to document the issues emerging from the classroom observations. The other coding process was of the mathematics classroom observations and interviews. In addition, a colleague in the Department of Mathematics and Science Education assisted in the analysis of the data. This was to provide an independent view of the data analysis.

Classroom observation: Five video recordings of the two participants teaching during the PTC internship were analysed. In analysing the videos, two videos were selected with respect to the student teachers' explanations, demonstrations, and responses to the students' responses. I then analysed the field-notes of the internship observations. In addition, I collected and reviewed the participants' internship books for more information on the participants' teaching practice experiences. The other analysis was of the mathematics class observations. The analysis focused on the mathematical development of the participants.

Interviews: I analysed the interview transcripts first by identifying coding units that addressed the effects of mathematics learning and its teaching. I then analysed other data sources and looked for any supporting evidence for any changes in the participants' beliefs about mathematics learning and its teaching.

Generating themes: In organizing data and generating evolving perceptions, transcripts of each interview and the observation notes were coded. Data were then grouped using the numbers 01 for changes in perceptions and 00 for lack of or minimum changes in views about mathematics and its teaching and learning. I then compared and contrasted the classroom observation notes and the interview transcriptions of the audio-tapes. Using this strategy, I was able to identify specific categories or themes of evolving perceptions in the participants' model for learning and teaching mathematics.

Comparing themes: Like Malone (1996) and Day (1996), I conducted comparison of themes at two levels. First, each participant's emerging themes were compared, and similarities and differences were noted. Secondly, a cross-case comparison was made.

Results

Analysis of the results revealed that the two participants shared two emerging themes: changes in the participants' beliefs about mathematics learning, and changes in their beliefs about mathematics classroom practices. The significant change in mathematics learning was in realizing that concept understanding rather than memorizing procedures was very important. Reviewing the participants' mathematics tests scripts, revealed that their mathematics content knowledge was more coherent than before. Participants were no longer placing more emphasis on learning algorithms. The interview analysis revealed that learning mathematics had improved. Khento reported that her mathematics learning is based on internalizing the feel of mathematics concepts. The fascination of understanding mathematics provided her with the desire to learn more mathematics and use different study styles. Changes in mathematics learning for Zozo was on focusing on conceptual understanding, and using different approaches in solving problems. During the interviews he said, " I no longer reproduce notes without understanding how each step is related to the other. I now try to understand the conceptual context of the problem."

The analysis of the results also revealed that following the completion of the methods course, participants had a coherent view about the mathematics pedagogical content knowledge. Mathematics learning was no longer regarded as a process of remembering the memorized procedures, but to conceptualise the connections between concepts. Statements like "Encourage the students to participate in their learning; create opportunities for them to succeed; and allow them to participate so that I could identify where they are having difficulties," were made during the interviews. For Khento, the focus was on understanding the connection between conceptual and procedural knowledge. She said, "Although I had always enjoyed learning maths, I used to have a limited conceptual knowledge. There were concepts that I could not adequately explain. Now I realise how important is conceptual understanding in maths learning."

With regard to changes in the participants' mathematics classroom practices, Zozo focused on teaching for understanding. This was exemplified by comments like: "I ask questions that help students to develop an understanding of the math question and project the expected answer. Asking precise questions helped me to be in control of the class. It also allowed the students the opportunity to engage in mathematical dialogue."

Analysis of the results also revealed that although the two participants appreciated some of the mathematics teaching and learning approaches, sometimes reservations were made. For example, participants observed that some of the approaches such as an instructional approach that is based on the constructivist view of learning may be problematic to both the teacher and the students. Khento exhibited little change in her beliefs about teaching mathematics. Although she acknowledged having learned different theories of teaching, she said, " I still do not approve of some of the teaching approaches that are be advocated for. I still believe that I can teach maths effectively using traditional methods." During observations, however, she attempted to engage students in activity-based learning, although on a minimum scale.

Emerging and evolving perceptions

The case of Zozo

Zozo's initial beliefs about mathematics and mathematics teaching

Zozo entered the programme with a strong belief that mathematics is not his favorite subject. This concern was evident when he commented: "Do we need this type of mathematics content if we are going back to teach in the primary schools? This may be suitable for those who are going to teach in secondary schools." His views about mathematics seemed to be more the norm than exceptions among primary school teachers. He expressed traditional views of mathematics. His views are that mathematics learning proceeds hierarchically, with children having to master the basic facts and procedures learned in rote manner before getting into application of activities. He indicated that his primary school mathematics teaching featured emphasizing knowing how to do problems. He said, "I showed children how to do problems. I was confident with this method of teaching. I sometimes tried to teach conceptually, but on very rare occasions." He considered remembering algorithms as an indication of knowing mathematics.

His mathematics study styles emphasized procedural understanding. He reported having used this study style at Primary Teacher Training College (PTTC) and was intending to use the same study style at the University level. He, however, acknowledged that his study style has some problems. He said, "The problem with my study style sometimes is that when problems are not clearly related, I always get confused and conclude that the problem is difficult."

Case of Khento

Khento's initial beliefs about mathematics and mathematics teaching

When entering the University programme, Khento's concern was more with mathematics teaching rather than with mathematics itself. During the initial interviews she described mathematics as "an enjoyable subject, challenging and requiring dedication." Khento's views about the mathematics content that they were studying were positive. She commented, "This content is challenging. It helps us to be on the same level with our secondary school colleagues."

Khento's hierarchical views of mathematics appeared to be a reflection of her views about how to teach mathematics. She did not approve of teaching mathematics using investigation and activity-based approaches. She commented,

> These methods are suitable for science teaching and for young children. I do not think older students can consider these activities as helping them much. Students want the teacher who delivers the stuff. Teaching mathematics requires teachers who explain the concepts and then demonstrate their relation.

Changes in teachers' beliefs about mathematics learning

Zozo experienced transitions in his beliefs during his teacher education programme in the University of Botswana. In contrast to his earlier beliefs, at the end of year 2 and during year 3, he had become more confident with the mathematics content. He was also appreciating the need to study the type of mathematics content, which he initially questioned as to its relevance to him as a primary school teacher.

Changes in beliefs about learning mathematics on the part of the participants is exemplified by the following quotes from the interviews:

> **Zozo:** When I came to the university, the study styles I used were based on memorizing procedures. Our mathematics lecturer advised us to learn mathematics conceptually. As I progressed through the programme, I changed my study styles and emphasis on conceptual understanding. This transition was not easy. I did not think it was going to work. But this seems helpful in making connections between mathematics topics. I am beginning to enjoy mathematics, although I sometimes get some problems wrong because of simple errors.
>
> **Khento:** I started to like mathematics more as from year 2. My lecturer made a clear link between mathematics and reality. I used to rely on learning algorithms. Now I use both algorithms and conceptual learning. This has boosted my understanding of mathematics. My big problem has been on mathematics teaching. My college mathematics teacher had always complained that my teaching was too much teacher talking. I always wanted to show children how to do a problem. On rare occasions I would like children to discuss a problem? My teaching was based on competition not co-operation.

Changes in teachers' beliefs about mathematics classroom practices

During the internship participants emphasized less memorization of facts in their instructional practices. Their teaching strategies were based on experiences to provide simulation of the learning situations. Their procedural emphasis was following conceptual teaching. They however, provided procedural strategies when helping less able student teachers. They expressed their intention to use more instructional strategies in primary schools that involve children than they did before.

From the observation, one interesting outcome was the emphasis by participants to address college students as 'teachers'. "Referring to them as 'teachers' gives the college student the sense of responsibility of being teachers."

> **Interviewer:** What do you think makes children make mistakes?
> **Khento:** When children make mistakes, I consider that to be the result of lack of concept understanding. That is why I 'teach' rather than only allow students to investigate alone. I always want to focus on understanding concepts rather than algorithms.
> **Interviewer:** What really do you mean when you say you teach?
> **Khento:** When I teach I may do a lot of things. I might lecture a little, ask questions, or give instructions. I believe this is what teaching is about.
> **Interviewer:** Do you think the methods course has helped you in modifying your teaching strategies?
> **Zozo:** I have changed some of my previous teaching styles. For example, I use children's mistakes more to help me focus on how to prepare and teach the next lesson. But not all I learned in this course is applicable. Conceptual teaching is still difficult for me.
> **Khento:** I think I have made some improvements in my teaching of mathematics. I am incorporating some of the teaching strategies I learned in the method course. But I still believe in my way of teaching. It emphasizes understanding followed by application.

In discussing their successful lessons, participants discussed them in terms of 'student teachers participation, interaction between student teachers, making generalizations, and making connections between concepts.' They also discussed their successful lessons in relation to the teacher's role. Zozo considered his role to be of a friend. Khento on the other hand considered her role to be both of an authority and a facilitator. In case of lessons that were considered unsuccessfully taught, the discussions were in terms of 'poor class interaction, too rigid, more answer oriented approach and less focused.'

The data about the effects of both the content and method courses upon teachers' perceptions revealed that teachers changed their beliefs about mathematics learning and teaching. The role of teacher training, however, should be seen in light of Fullan's (1991) argument that change at the individual level is a process whereby individuals alter their ways of thinking. This is not an easy task since peoples' beliefs are part of a deeply rooted belief system based on perceptions of their role as students or teachers.

Discussion

Zozo and Khento's emerging and evolving perceptions were compared separately. At the same time similarities and differences among the participants' views about mathematics and mathematics teaching were observed. Zozo was more concerned with mathematics content than Khento. Khento's concern was with mathematics teaching. Her beliefs about mathematics teaching were so strong that it seemed impossible to modify them. She, however, acknowledged and practized some of the teaching strategies she learned in the methods course. In her internship experiences, she used methods such as activity-based approaches, which she earlier considered to be only suitable for younger children. On the other hand, Zozo's beliefs about mathematics teaching were not strongly held. His beliefs seemed to be based on familiarity with a particular method of teaching rather than being held with any conviction.

During the initial interviews about their mathematics teaching experiences in primary schools, the participants reported emphasizing procedural teaching. At the end of year 3 the participants had developed a positive view about mathematics and mathematics teaching. Although there is reason to believe that the participants' views about mathematics and mathematics teaching and learning have undergone some changes, it is difficult to conclude that the changes are due to the methods course alone. Significant changes in the participants' learning and teaching mathematics may require fundamental changes in their beliefs about the nature of mathematics and its teaching. A number of studies have pointed to the centrality of the beliefs as they relate to teachers' teaching actions (Thompson, 1984, 1992, Fernandes, 1995).

Changes in teachers' beliefs about mathematics and mathematics teaching come slowly over a long period of time. These changes with some teachers may sometimes accompany changes in classroom practices. Sometimes, however, changes may not occur. This was evident in the case of Khento. She maintained her beliefs about mathematics teaching. Green's (1971) notion of nonevidential beliefs is relevant

when considering Khento's beliefs about mathematics teaching. The teaching style that Khento uses (expository and based on concept development) is the same as that reported to be used very successfully by mathematics teachers in Japan. Japanese teachers are focused on helping students understand mathematical concepts. In addition, they view children's mathematical errors as indications of concepts which still must be learned and not as failures of the children (Stevenson & Stigler, 1992).

Conclusion

Research on beliefs of experienced primary school teachers who come to the university for further studies is very crucial in understanding how these teachers view their perception of mathematics and mathematics teaching after spending sometime in the schools and the contribution the in-service programme is making towards teacher change. This research, therefore, adds to the knowledge on in-service primary school teachers' beliefs on mathematics and its teaching. In addition, the study traces and highlights transitions that occurred as in-service primary teachers began and progressed through an in-service teacher education programme.

Teacher education has a responsibility to incorporate teachers' beliefs about mathematics and mathematics teaching in its teacher training programme. Methods courses are valuable for exposing student teachers to different teaching approaches. But these courses could also be valuable if they place emphasis on making in-service teachers aware of how their teaching actions are influenced by their personal perceptions of mathematics and in turn how these actions affect their instructional practices.

The task of altering in-service primary school teachers' beliefs about mathematics and its teaching is a challenge for teacher educators, particularly in light of research (see Borko *et al.*, 1992; and Raymond & Santos, 1995) showing that one or two semesters is not enough to effect any lasting changes in beliefs. The role of teacher education should be seen as a process whereby in-service teachers alter their ways of thinking and the ways they teach. This is not easy because in-service teachers' beliefs are deeply rooted in their belief structures based on the experiences they had since early primary school and during their teaching careers. In addition, the beliefs changes the in-service teachers gained during the training period might gradually fade away unless the teachers receive support. The factors that have initiated their old teaching practices and conceptions could re-appear.

In helping teachers, however, to work toward practices that are consistent with beliefs about mathematics and its teaching, mathematics educators should be particularly careful not to ignore the fact that belief changes may come from different experiences rather than from teacher education programme itself. Teacher educators should attempt to separate changes that are due to the individual's desire to change from changes that are due to the content of the method courses taken. The learner may also modify his/her constructs when a relevant person places a particular emphasis on something (Bauersfeld, 1994). The content of the course may be structured in a manner that appeals to an individual to consider a change in his/her beliefs about mathematics without having any strong conviction to change. If in-service primary school teachers are to alter their views about mathematics and its teaching, they may need to appreciate a willingness to change and re-examining a whole network of their beliefs about mathematics and mathematics teaching and their views about how one acquires mathematics knowledge.

Finally, research is necessary to identify more precisely the teacher education strategies that result in changes in in-service primary school teachers' views about mathematics and mathematics teaching. Understanding beliefs requires making inferences about individuals' underlying states, inferences fraught with difficulty because individuals are either unable or unwillingly, to accurately represent their beliefs (Pajeres, 1992). Inferences about beliefs require assessment of what individuals say, intend, and do. Teachers' verbal expressions, predispositions to action, and teaching behaviors must be thoroughly probed — including asking the in-service teachers how a particular action could be improved. This could help elicit more ideas that could help in the interpretation of what actually influence teachers' changes in their belief systems.

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