Action Research to Study Classroom Impact: is it possible?

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ABSTRACT: In recent years, a discourse is emerging in education that emphasises the study of the impact of in-service teacher education on student outcomes (more often than not student outcomes are seen in the form of test scores of academic achievement). Implicit in this discourse is the view that the impact of in-service teacher education is directly observable on students' outcomes, suggesting that the variables in a school or classroom are connected in some kind of a causal link. However, it is problematic to view variables in a social setting such as a school or a classroom as being in causal relationships because social settings are complex so that it is not possible to control the variables or the outcomes. Hence, one cannot convincingly study the outcomes without also studying the process and its complexity. In this article, I describe an action research study undertaken to study the impact in the classroom, of new teaching strategies introduced as part of an in-service teacher education programme in Karachi, Pakistan. By describing this study I mean to suggest that action research is an appropriate methodology to study the impact of in-service teacher education.

Keywords: classroom impact; action research; in-service teacher education

Introduction

In recent years a discourse is emerging in education, which emphasises the study of the impact of in-service teacher education on student outcomes (more often than not student outcomes are seen in the form of test scores of academic achievement). Implicit in this discourse is the view that the impact of in-service teacher education is directly observable on students' outcomes, suggesting that the variables in a school or classroom are connected in some kind of a causal link (Burchell et al, 2002; Flecknoe, 2002). However, it is problematic to view variables in a social setting such as a school or a classroom as being in causal relationships because social settings are complex, so that it is not possible to control the variables or the outcomes.

Hence, one cannot convincingly study the outcomes without also studying the process and its complexity.

Furthermore, how one views impact has implications for the study of impact. For example, impact seen as immediate and directly observable on student outcomes, would suggest a research design based on a pre- and post-test where students would be administered a test prior to and after the intervention, and the difference in the test scores seen as evidence of impact. However, impact seen as a process of change that is adaptive in nature, enabling those implementing new ideas or practices to interpret and adapt them would suggest a study design that takes in to account the process of change, and not just the outcomes. In what follows, I discuss further the points that I make above.

In their discussion on issues involved in measuring impact of teacher professional development Flecknoe (2002) maintains that:

> Even the clearest cut, most confident case would have difficulty persuading some colleagues that causality had been demonstrated. It is often possible, for instance, that the teacher who attends continuing professional development in her own time often at her own expense, is one who is likely to raise the achievement of her pupils without the aid of a programme of continuing professional development in an institution of higher education. It is possible that the reported impact in such circumstances is merely the reporting of what would have occurred in any case. (p. 133)

On a similar note, Fielding (2003) unpicks the presumptions and presuppositions of impact. In doing so he asked teachers whom he worked with what came to their mind with the notion of impact. He reports that some words and phrases that were invariably in the list produced include 'surface', 'easily visible', 'one way', 'measurable' and 'immediate'. Fielding goes on to suggests some other 'worries' around which impact could be described and studied, which would produce a list of words and phrases such as: 'depth', 'things that are not immediately apparent', 'two way/reciprocal/dialogic demands', 'considered, negotiated judgment', 'patience', 'creativity', 'gradual incremental/unpredictable approaches' (Fielding, 2003, p. 291).

Implicit in Flecknoe's and Fielding's discussion is a recognition that the impact of teacher professional development on students, seen as a causally linked, and directly visible change is a problematic notion. It is problematic because in social situations variables are in a complex relationship so that they can neither be isolated and controlled, nor a direct causal link be established. Instead, impact of an intervention in a social setting such as a school could be seen as a process of change that cannot be assessed simply by measuring 'current practice and outcomes', because of the uncertainty about what prior inputs, implementation processes and contextual factors actually explain why things are the way they are. It is important to explore the 'process of change' intervening between the source

inputs, and the current practices and status, and the contextual factors influencing the change process in an interactive way throughout the course of the implementation. This exploration would enable an understanding of the process of implementation of the intervention along with the outcomes of the intervention.

A methodological implication of this view of studying impact would be to look at what actually happens in the classrooms to understand why the intervention works or does not work. Evidence from case studies and studies using qualitative methodologies could be used to help illuminate why particular interventions are effective, i.e. the process issues or the reasons why particular programmes or participant characteristics seem to have an effect on outcomes (Evans & Benefield, 2001).

I maintain that conducting action research studies would be appropriate to understand how and if in-service teacher education brings about a change the classroom. This is because action research is about bringing about an improvement in a social situation through participation in cycles of planning, acting, observing and reflecting, thereby creating possibilities for change and transformation (Pedretti, 1996; Kemmis & McTaggart, 2000; Phelps & Hase, 2002). While research on change (e.g. Fullan, 2001) has shown that when new ideas and practices are introduced in schools and classrooms, they are interpreted and adapted by the teachers (and others) who put them into practice within the context of their own situation, existing beliefs and practices. Thus, the movement from source inputs in teacher education programmes to student outcomes is an adaptive process and action research provides an appropriate methodological approach to study this process and its outcomes.

Retallick & Mithani (2003) used an action research approach to do an impact study. These two researchers went into a school for a period of eight weeks to engage in action research to study the impact of certain programmatic inputs on schools, 6 months after the programme had ended. They agree that as action research and impact are conceptually both about change and improvement, it would be possible to observe the way that a programme impact works its way through a school over a period of time.

In this article, I describe an action research study undertaken to study the impact in the classroom of new teaching strategies introduced as part of an in-service teacher education programme in Karachi, Pakistan. By describing this study, I mean to suggest that action research is an appropriate methodology to study the impact of in-service teacher education.

Background

The Aga Khan University Institute for Educational Development (AKU-IED) was established in 1993. One purpose of establishing it was to develop models of school improvement through further education and professional development of teachers. The Institute offers a range of in-service

programmes including certificate programmes, advanced diploma programmes and Master's programmes for teachers.

This article reports on findings from an action research study undertaken by myself and a group of colleagues who were teaching the advanced diploma in education: mathematics (class of 2003). In the class of 2003, there were 15 mathematics teachers from schools in Karachi and the instructional team including myself comprised four tutors.

The main aim of the programme was to develop exemplary teachers who are reflective practitioners. Teachers are sponsored by their schools in the advanced diploma, and it is designed such that seminars are held at AKU-IED during summer and winter breaks, and on Saturdays when most schools are off. During term-time, tutors visit the participants in the school. The purposes of field visits include:

- provision of classroom support to participants in their efforts to implement their learning in real classrooms;
- identification of areas where participants require further support;
- the enabling of reflection.

Hence, to support reflection and enable a questioning stance towards their practice participants were expected to engage in small-scale action research projects. The cyclical nature of the programme, where AKU-IED-based sessions are followed by periods of intensive work in the field lends itself to conducting action research. In the class of 2003, the focus of participants' action research was studying the process of the implementation of teaching strategies introduced in the advanced diploma.

As part of the advanced diploma course work participants of this cohort were introduced to certain key strategies for enabling mathematics learning and for assessing the processes of students' learning. These included:

- The do-talk-record framework (Open University, UK; Brissenden, 1988). According to this framework students are encouraged to do the mathematics in pairs or small groups. Concrete and semi concrete materials are provided to aid the work. Students are expected to record their mathematics using words, pictures or symbols and discuss the rationale of their decisions.
- The cooperative learning strategies (Bennet et al, 1991; Johnson et al, 1993). According to Johnson et al (1993, pp. 6-12), there are five basic elements that should be incorporated in small group work to make it cooperative learning. These are: (a) individual accountability, i.e. when performance of each individual is evaluated, feedback is given both to the individual and the group, and the student is held responsible by the group if not working responsibly; (b) face-to-face interactions, i.e. when individuals encourage and facilitate each group member's effort to achieve group goals; (c) positive interdependence, i.e. all group members believe that they, and all other members of the team are essential for the success of the team; (d) group processing, e.g. reflection on group sessions to describe which actions of the members were effective, and

which ineffective and deciding which actions to continue with, to modify or discard; and (e) social skills, i.e. use of appropriate interpersonal skills in small group work.
- The problem solving strategies (Polya, 1957).

These strategies enable a focus on the problem solving process by suggesting iterative cycles of plan-act-review, while mathematical problems are beings solved.

One rationale for introducing these strategies in the advanced diploma programme was that the effectiveness of these strategies was research-based (e.g. Pimm, 1990; Etonado & Garcia, 2003). Furthermore, these strategies enabled a focus on the process of developing mathematical thinking along with the product that is invariably in the form of a right answer. This focus on the process of developing mathematical thinking is significant in the context of Pakistani classrooms, which are characterised by an emphasis on only the product of mathematics tasks.

Methodology

This study was designed as 'nested action research', i.e. multiple action research studies were woven into the fabric of the advanced diploma programme. The programme participants engaged in individual action research projects. At another level the tutor-researchers also engaged in action research. Through seminars and meetings there were opportunities for the participants and the tutor-researchers to interact and share the research process and findings. However, this article reports the action research undertaken by one tutor-researcher, i.e. myself.

With my colleagues I identified the teaching of the above mentioned innovative strategies and their classroom implementation as the area of our practice that we would study. The research was over the period August 2002-July 2003, this meant that during the course of the research in the school, one academic year ended in March 2003 and the new academic year began in April 2003. The study was so designed that over a period of 1 year each tutor-researcher worked with three or four classroom teachers who were participating in the programme. This work involved providing the field support that has been described above in the section on background. The action research was woven into the process of teaching that we undertook as tutors. Hence, our teaching in the seminars at AKU-IED was followed up with classroom support. Subsequent teaching was based on ongoing reflection on issues and questions emerging from the field. A purpose of the action research undertaken by the tutor-researchers was to generate local evidence of impact and look for micro-impacts that would help justify teaching these methods to teachers more generally. Moreover, it would test the context appropriateness of these strategies and, thereby, inform the curriculum of the teacher professional development programme.

I was a tutor-researcher working with four teachers, Amna, Tehmina, Naima, Shanila (pseudonyms). These were mid-career women with 5-15

years of experience. For reasons of space and to enable a deeper discussion, I report findings from my work with Tehmina.

The main research question was:

- How do selected strategies implemented in the classroom by the teacher contribute to teaching and learning processes?

Subsidiary questions were:

- How are these selected strategies defined?
- What are the benefits if any of these selected strategies for students' learning?
- What issues and questions arise in the context of using these strategies?

By selected strategies are meant those teaching strategies introduced as part of the programme.

Tehmina

Tehmina was a young mathematics teacher from a government middle school in Karachi. She had about 13 years of teaching experience. In the interview for selection to the advanced diploma programme, she came across as highly motivated in working towards improving her classroom practice. Middle school means that there are classes from grades 6 to 8. Tehmina taught mathematics to all the three classes. For her research she worked with students of class VII (girls, 12-13 years) and continued with them when they were promoted to class VIII in the new academic year. My observations at the beginning of the programme showed that the teaching and learning in the classroom was mainly teacher directed, and limited to the syllabus in the prescribed textbook (e.g. Sheikh et al, 1998). The teacher would work through 'sums' or 'exercise questions' on the blackboard. These were mathematics tasks given in the textbook, and usually required students to apply a rule and find an answer. Once the teacher had worked through and explained a few of the 'exercise questions' the students would quietly and individually work through the rest of the exercise. Students did not work collaboratively at any stage of the lesson. At the end of the teaching period the teacher would collect students' work to mark. In the annual school examination students were tested on a selection of the same items taken from the exercises in the textbook.

This was a school in an underprivileged, highly congested area of Karachi. According to the information provided to me by the teacher, almost all the students came from poor working class homes in the area. The school had recently gone through an upheaval resulting from decisions taken in government offices. A consequence of these decisions was that there was uncertainty regarding the future of the school, the jobs that the teachers had and the fate of the students enrolled in the school. Students were very irregular in their attendance, which had consequences for the group formation and the work that Tehmina proposed to do in her class.

Tehmina identified the use of concrete materials by students as they worked in small groups at mathematics tasks, as a teaching strategy that she would focus on during her research. Based on my discussions and my observations in her classroom I inferred that the problem tasks she used were different from those she used before she initiated change in her class. The change was that the problem tasks did not come directly from those given in the prescribed textbook. They were designed or selected by Tehmina and mostly required students to work in groups using provided concrete material. Students were not required to follow fixed procedures for solving the problems. Instead, they were free to use the solution strategies they found suitable and were expected to explain them to others in the group and in the classroom. Moreover, the directions in the problem tasks required students to explain their solutions to others in the group or to the teacher.

The new ways of working emphasised collaboration as opposed to the focus on individual work. Discussion of mathematics ideas was part of the task directions. The social setting of sitting in small groups also encouraged this discussion of the mathematics being learnt. Moreover, different groups of students were expected to share with the whole class their solutions to problem tasks, arrived at as a result of the group discussions. From her emphasis on enabling students to use their own solutions and explain solutions in their own words I inferred that a focus of change was to enable students to reason through their mathematics. It appeared that Tehmina was drawing upon the salient features of the three main strategies introduced in the programme, i.e. problem-solving strategies, cooperative learning strategies and the do-talk-record framework. In a subsequent conversation she pointed out that students' irregular attendance was creating a problem because she wanted them to work in groups, but absenteeism meant that the groups did not get an opportunity to work consistently with each other. She said that to address this issue she had a conversation with the students explaining the issues arising from their irregularity. She also visited the parents of the irregular children and explained to them the changed nature of her work in the classroom, the significance of students coming to school every day so that others in the group did not suffer because of changed group structure.

In her journal she wrote extensively about her thinking and rationale for selecting the new approaches to teaching. For example, according to her she had identified this area because:

> In my 13 years I have not used this approach to teaching which I am using now after my training at IED. In the sessions at IED I learnt while working on a simple activity on investigating area and perimeter that children do not learn just by telling or by making shapes on the blackboard. Children won't be able to learn until they do it themselves and until they get a chance to touch it themselves. (Tehmina's Journal entry, translated from Urdu)

Elsewhere in her journal she elaborated on the reasons for using these teaching strategies in her class:

> I have been teaching in different schools for the past 13 years. In these 13 years I have observed that children depend solely on their teacher. Keeping this observation in mind certain questions come to my mind. If students don't understand, why is that so? Why do they feel shy in working in groups? Will using concrete materials influence their learning? If not then what factors would I need to keep in mind? (Tehmina's Journal entry, translated from Urdu)

How I Worked with Tehmina

In what follows I describe briefly how I worked with Tehmina, the activities undertaken and their rationale.

Classroom Observation

Over a period of 1 year every month I visited Tehmina in her school. Classroom observation was an important element of these visits. During observations I played the role of a tutor and researcher. As a tutor I introduced Tehmina to innovative approaches to teaching mathematics effectively. As a researcher I observed and analysed with her the classroom processes of teaching and learning. As part of my observation, I also looked closely at a group of students. During group work a small tape recorder was placed on the table to record the group interactions. During whole class work this tape recorder was kept on the teacher's desk.

Pre-observation Conference and Post-Observation Conference with the Teachers

Besides classroom observations, there were pre- and post-observation conferences with Tehmina. In the pre-observation conferences she shared her lesson plans, sought input on ideas pertaining to the teaching of a particular topic, discussed possible issues in implementing the particular strategy in the classroom. In the post- observation conference we analysed the lesson. At times, we ended working through the mathematics tasks that she intended to use in class or there were tasks that enabled us to clarify issues arising out of classroom observations.

Reflective Journals

The teacher participants and each tutor including myself maintained reflective journals. These journals not only provided an account of emerging issues and questions, but also encouraged us to make our thinking explicit, thus providing a forum for conscious and deliberate thinking on action once

it had occurred. The teacher participants, in my case Tehmina, shared their journal with the field tutor assigned, i.e. myself. There were instances when I shared extracts of my journal with her.

Tutor-Researcher Meetings

Over the course of the research the tutor-researchers met regularly. There were at least 20 meetings averaging 90 minutes approximately. The proceedings of these meetings were tape-recorded. These tapes were transcribed and transcripts forwarded as email attachments to all team members. A purpose of these meetings was to share findings from the ongoing field work, identify issues and questions, and engage in cross-analysis that could feed back into our thinking about the study. For example, it came out in our collective deliberation that managing time effectively when teaching through innovative strategies was an issue that was common to all classrooms. Hence, in the teaching sessions at AKU-IED we scheduled some sessions on managing time effectively.

Analysis was ongoing and not simply at the end when all the data had been generated. Thus, analysis was an integral part of the methodology and the ongoing analysis guided subsequent fieldwork. To sustain this ongoing analysis the team met regularly at least once a month as described above. Besides the team meetings, reflective journals and discussions with the programme participants provided an opportunity to analyse, and to keep a record of the developing thinking, insights gained and issues that emerged.

Findings

In this section I discuss the findings from my work with Tehmina. To contextualise the findings and subsequent discussion, I share two examples of lessons on 'sets' planned and taught by her. Sets is a topic included in the middle school mathematics curriculum. Tehmina taught the topic of 'sets' twice during the course of the research. Once, at the end of the academic year she taught an introductory lesson on 'sets' to class VII. She next taught sets a few weeks later at the beginning of class VIII. Here, she developed the topic further and also introduced concepts such as equal and equivalent sets. I chose these lessons because they best exemplify the general issues and findings from the study.

Lesson I

This was a lesson in class VII on the topic of 'sets and intersection and union of sets'. As I observed this lesson, I saw that Tehmina started by giving out handfuls of tamarind seeds and date seeds to small groups of students. She asked the students to make sets from the seeds she had given to them. Each group made two sets, one of tamarind seeds and the other of date seeds. She went around and monitored the work in progress. Once all

the groups had made sets using the seeds she provided a formal definition of a set as follows:

> A set is a collection of distinct objects.

Once the definition was given she wrote on the blackboard the following examples of sets and pointed out the convention of putting the brackets to signify a set and commas to separate the members of a set:

> A = {a, b, c}
> B = {1,2,3,4}

The following set was provided to show that members of a set should not be repeated because each member is distinct:

> A = {a, a, b, c}

The students were then asked to move on to the next task where they had to form union and intersection of the sets that they had already made with the seeds, and then answer questions 1-8 shown below (see the detailed lesson plan in Appendix I):

1. How will you write the sets?
2. How many members are there in each set?
3. How will you write the two sets together?
4. If when writing the two sets together the elements are the same will you write them repeatedly or will you write them only once?
5. Do the elements of the set have to be written in any particular order or not?
6. If there are members common in two sets what is such a set called?
7. What are the symbols of Union Set and Intersection set?
8. What will be the elements of the Intersection Set of two sets that do not have any common member?

At this stage when students worked on questions 1-8 there was some confusion in the class. This was because one student raised her hand and said that, in her group, they did not know how to represent using formal notation, the two sets that she and her group mates had formed with the six tamarind seeds and five date seeds, respectively. Also, to the question how many members there were in each of the two sets that the students had made using the seeds, one student replied that it had 'one member only' because the date seeds were the same and members of a set are not repeated. Tehmina accepted this response as correct!

For me, as an observer, this was an awkward and difficult moment. I had to make the tough decision of whether or not to intervene. I decided to have a quick word with Tehmina when she came towards the back of the classroom. I pointed out to her an example that she had used in an earlier conversation that of a tea set. I asked her how many elements were there in a tea set she said two: one teapot and the other cup. However, there are six cups. To this she said 'yes, but they are repeated, and so we write them only once!' It was not possible for me to have a more detailed conversation with

her there. Tehmina recognised that she was teaching something wrong and quickly moved away from concrete materials and everyday examples. She reverted to the following textbook examples:

- How will you write the set of first four negative integers?
- How will you write the set of first 100 natural numbers?
- How will you write the set of letters in the English alphabet?

In the post-lesson discussion I suggested to Tehmina that she do some work to enhance her own understanding of the notion of sets, and how its members were defined and represented conventionally. I provided her with appropriate readings and at a subsequent date we did together some related mathematical tasks and discussed the concept.

Reflecting on the issues that arose from her sets lessons she wrote:

> During the lesson I had realised that those resource materials that I had used to teach sets were not appropriate for the purpose. Instead children were getting more confused with it. Hence, I had realised that I should have used some other teaching aids with clear and different things and which were more suitable for teaching sets ... (Tehmina's Journal)

Lesson II

This was the second lesson on sets in class VIII. The first was a review of work done on sets when the students were in class VII. The main objective of this lesson was to enable students to learn what are 'equal sets and equivalent sets', and how to notate them. She started by showing students two sets and asked them questions about the number of elements in each set and the difference in the elements in the two sets. She then explained to them that two sets with an equal number of elements were equivalent, but were only equal if the elements were the same and equal in number. Next she gave a handful of colourful buttons to small groups of students, and asked them to make equal and equivalent sets with those buttons. Finally, she asked each student to work individually at the table shown in the lesson plan in Appendix II.

My observations showed that when the class worked with colourful buttons Mehvish (a student in the group I observed) easily formed a variety of sets and identified equivalent, equal and unequal sets. However, in the final activity, where Tehmina evaluated students' knowledge of equal and equivalent sets, Mehvish who had worked successfully with buttons identifying sets correctly as equal and/or equivalent, identified the following two sets as equal:

A = {b, o, y}
B = {boy}

Mathematically, the two sets above are not equal because set A has three members, while set B has one member. The commas are meant to separate

each member. However, it appears that Mehvish had not recognised the significance of commas in the formal notation. This could have been due to the fact that when making sets with concrete materials she did not need to put commas to separate the distinct members of the set. Hence, the very advantage in enabling students to move away from the formal symbolism of mathematics became an issue when students could not follow some of the conventions that are particular to symbolic mathematical language.

Examination Results

This change in the use of teaching materials was also reflected in a change in the kinds of questions that Tehmina set for students to work at in the examinations. For example, she now had tasks that did not directly come from exercises in the textbook. Also, in the examination she no longer asked the students to follow one prescribed method for solution. For example, consider the following test item taken from the end of the year examination paper prepared by Tehmina:

> My father brought a cake and my mother divided it into 8 equal pieces. I ate one piece and my brother ate one piece. What fraction of the cake was eaten and what fraction of the cake is left?

The test item did not come from the textbook. Furthermore, when I looked at the solutions provided by the students I found that some had used pictures supported with verbal explanations to provide a solution, while others had used formal procedures with symbolic manipulations for their solutions. This variety in approaches to solution was noteworthy because traditionally students are asked to use a particular method to solve the problems set for them.

Towards the end of the programme when Tehmina was writing her own action research report she compared the results of the annual examinations from two successive years. She did an analysis of the examination results of these students' performance when they were in class VI, i.e. the previous year, and their result when they were in class VII, i.e. the year when they were taught by Tehmina through the use of innovative strategies. Her results showed a marked improvement in students' performance. The overall percentage of students who passed the school annual examination remained the same in both years. However, significantly there was improvement in the average percentage secured by the class. Whereas in the previous year the class average was 34%. In the next year for the same group of students the class average was 67%.

Discussion of Findings

In this section, I discuss the findings pertaining to the nature of change as it unfolded in Tehmina's classroom. I discuss the change in the student

learning process and outcomes, teaching practice, and teachers' enhanced understanding of classroom issues and of the subject knowledge.

Students' Learning Outcomes

As students worked at mathematics tasks in the classrooms where Tehmina used the teaching strategies described above there was evidence of positive impact on their learning process and outcomes. Here, outcomes have a broader focus including academic achievement. A reason for including this broader focus is that a lot of emphasis in the advanced diploma programme and, hence, by the teachers was given in encouraging students to develop skills and attributes to enable them to work cooperatively with peers in the classroom.

This impact on non-academic outcomes was evident in the form of improved confidence and social skills. It could be seen from the kinds of questions that students asked in the classroom that the discourse in this classroom was broader and, richer, than the discourse in a classroom where the textbook is the only resource and teacher transmission is the only strategy being used. Students in the classroom began to participate more. They were no longer simply listening to the teacher or working quietly in their exercise books. Rather they were heard talking to each other. Initially, my observations showed that they whispered to each other or giggled self-consciously. However, as time progressed they began to volunteer to participate in the whole group presentation of each group's work. They would smile and acknowledge me, whereas in the beginning they tended to look away from me.

Impact was also seen on students' academic achievement. The average percentage secured by the class was higher. An implication of a higher class average could be that the brighter students had benefited more than the weaker students. However, when I looked at the individual scores it appeared that some high achievers had secured more marks but there was also a decrease in the number of students securing lower marks, thereby bringing up the class average. The marked difference in the performance results of the students suggests that these students were able to perform better in mathematics. There could be several reasons for this change for the better in students' performance. The students were in a higher grade, at least one level above the previous grade. Types of questions included in the examination paper were different. A striking feature that stands out is the different approach to learning that the students engaged with during the course of their work at mathematics tasks. Improved students' achievement could be indicative of the impact of the innovative teaching.

Teaching Practice

Tehmina's teaching through out the year involved using instructional materials, such as worksheets and group tasks that covered the content outlined in the textbook. However, the questions and problems were

necessarily different. The tasks that Tehmina designed so that they were amenable to the use of concrete materials were invariably richer and broader than the tasks taken directly from the textbook because they were usually more open-ended, and allowed for the use of students' own creative approaches to problem solving.

A consequence possibly of organising her teaching around cooperative group tasks was a positive change in the teaching sequence that Tehmina began to use. For example, the textbook starts with a definition of the concept, say, sets. From my experience as a mathematics teacher educator I know that the teachers, including Tehmina, are used to following the sequence of the content laid out in the textbook, which meant that they would start by giving out the definition of a set and then ask students to work thought the exercise given in the textbook. However, observations showed that during her teaching Tehmina provided multiple opportunities for students to work with examples and non-examples of concept, and then came to the definition of the concept. Skemp (1986) maintains that enabling students to abstract the key features of a concept from example and non-examples is a sound approach as compared to starting with a general definition, and providing examples to elaborate the definition.

Teachers' Enhanced Understanding

Participating in the advanced diploma contributed greatly to the teachers' enhanced understanding of mathematics. Specifically, planning to teach through innovative or different approaches led to situations that enabled the teacher to recognise her own limited understanding of mathematics and take steps to address the situation. For example, in Lesson I Tehmina asked students to form sets and give the number of members that the set had using the material she had provided. These were handfuls of date stones. When the groups started to work at the task they came up with an issue. Does a set of five date seeds contain five elements or one. This confusion arose because of Tehmina's instruction that the members of a set are not repeated. It was further compounded by another example she provided, i.e. a tea set with teapot and six tea cups has two members because the cups are not be repeated. It was apparent that she was not taking into account the fact that each cup, and in the earlier case each date stone was a concrete entity in its own right and therefore had to be acknowledged as a distinct member of the set. However, when I observed Tehmina teach 'sets' again in class VIII, my observations did not reveal any gaps in her understanding of this topic. This suggests that the additional work that she did to improve her own understanding of 'sets' enabled her to fill the gaps in her knowledge.

Concluding Reflections

To conclude, the advanced diploma in education: mathematics was a strong programme for teacher professional development through in-service

education. Its major strength was its field-based nature, and an emphasis on critical reflection and analysis as teachers transferred their learning to the reality of their classroom. Hence, teachers were constantly monitoring the consequences for students of the change they introduced in their practice. Findings and discussion earlier in the article show that classroom support provided by the tutor-researcher played an important role in enabling teacher reflection. However, this one-to-one support between the teacher and the tutor-researcher is resource intensive and cannot be sustained over extensive periods of time. Hence, a recommendation would be that support structures within the school be explored. An implication of this suggestion is that teachers in groups introduce new practices in their respective classrooms and conduct inquiry in the process. This would provide them with the opportunity of supporting each other. Indeed, peer support in the form of 'peer-coaching' is well documented as a robust form of in-service teacher professional development (Showers & Joyce, 1996; Joyce & Showers, 1980).

As a tutor-researcher, taking an action research approach to study the classroom change meant that I could:

- study the process as new teaching methods found their way in the real classroom;
- consider issues and questions that arose in the course of implementation;
- identify what changed in the process.

For example, the study showed that Tehmina adapted and modified the three teaching strategies introduced in the programme by pulling out elements from each that she believed were important for enabling classroom learning. So, her classroom practice changed to enable students to work with each other in small groups as they used materials provided to solve mathematics problems. Change was also visible in how the students learnt mathematics in the classroom, their social skills, and the quality of mathematics that they did in the class. However, in the course of this change a number of factors emerged as influencing the course of change. For example, Tehmina's own subject knowledge was a factor that needed to be worked with to enable her to teach effectively through the new methods.

Similarly, a significant impact (though not an intended one) was improved attendance and regularity of students in coming to school. An assumption implicit in recommending teaching and learning strategies based on students' mutual collaboration was that students would be regular in their attendance in schools. As indicated earlier, this assumption did not hold in the case of Tehmina's classroom and led to a sequence of events where there was a positive impact on classroom attendance.

I conclude on the note that action research was a suitable approach to study the impact of selected strategies introduced as part of the advanced diploma because it enabled the study of the process of implementation of strategies, thereby identifying the factors that were enabling change and issues that were acting as obstacles to change.

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APPENDIX I

Lesson I: sets and union and intersection of sets

Aim:
To develop the concepts of set, intersection and union of sets

Objectives:
Students should be able to:

- define set in their own words;
- find union and intersection of given sets and state the definition;
- be able to write the sets, and their union and intersection.

Activity I

Students work in groups. They are asked to make two sets using concrete material provided to them. These materials included date seeds and tamarind seeds.

Activity II

Group representative will come to the front of the classroom and answer the following questions:

1. How will you write the sets?
2. How many members are there in each set?
3. How will you write the two sets together?
4. If when writing the two sets together the elements are the same will you write them repeatedly or will you write them only once?
5. Do the elements of the set have to be written in any particular order or not?
6. If there are members common in two sets what is such a set called?
7. What are the symbols of Union Set and Intersection set?
8. What will be the elements of the Intersection Set of two sets that do not have any common member?

Activity III

Individual work. Students complete the work sheet requiring them to find union sets and intersection sets of given sets.

APPENDIX II

Lesson II: equal sets and equivalent sets

Aim:
To introduce the concept of equal and equivalent sets.

Activity I

Tehmina started by showing the students a chart on which were the following pairs of sets were shown and asked questions to enable students to consider the similarities and differences in the two pairs of sets:

A = {Lion, Zebra, Camel} B = {Camel, Dog, Zebra}

and

C = {a, b, c, d} D = {b, e, d, c, a}

Activity II

Students in groups were given a handful of buttons of different colour and size. Using the material provided make equal and equivalent sets.

Activity III

Individual students were invited, in turn, to come and place a tick in the appropriate column on a chart and state which of the following sets are equal, unequal and equivalent.

No:	Pair of sets:	Equal:	Unequal:	Equivalent:
1	A = {m, a , s} B = {s, a, m}			
2	A = {b, o , y} B = {boy}			
3	A = {January, June, July} B = {names of months starting with J}			
4	C = {+, −, ÷, •} D = {=, %, +, }			
5	A = {a, b, c, d, e, f} B = {e, i, u, s}			
6	C = {bus, car, scale} D = {pen, pencil, marker}			
7	D = {1, 2, 3, 4} B = {4, 3, 1, 2}			
8	D = {Red, blue, green} B = {a, b, c}			