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Evaluating action research as a model for school-based professional development of secondary mathematics teachers in the Philippines

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USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

Abstract

This study documented a school-based professional development activity conducted in a secondary school in the Philippines where five secondary mathematics teachers and the head of the school participated in a program of action research. The effectiveness of action research as a form of professional development and the constraints in using this form of professional development in the Philippines were evaluated based on the changes on teachers in terms of pedagogical knowledge, practices and beliefs.

Qualitative research techniques were used. The methodology included questionnaires, interviews, class observations and diaries.

The results indicated that the involvement of the participants in the action research has broadened their pedagogical knowledge and changed their teaching practices and beliefs. They started to use practical work; recognized and used a variety of resources including manipulatives; allowed students to do group activities and started trialing student-centered approaches. The teachers seemed to prefer an action research approach to professional development.

This study found that the major constraints to professional growth of teachers arose from their students' attitudes and abilities, classroom factors and the educational system in general.

Finally, the research has demonstrated that within the parameters of certain constraints, the action research process can be successfully carried out by secondary mathematics teachers in the Philippines and that this form of professional development has positive effects on teachers' professional growth.

Declaration

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

(ii) contain any material previously published or written by another person except where due reference is made in the text; or

(iii) contain any defamatory material.

Signature

Date

26 February 1998

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List of Abbreviations

APEC	Asia Pacific Economic Cooperation
ARMM	Autonomous Region of Muslim Mindanao
BSE	Bureau of Secondary Education
CAI	Computer Aided Instruction
CAR	Cordillera Autonomous Region
CENTREX	Center for Excellence
CGI	Cognitively Guided Instruction
DECS	Department of Education Culture and Sports
DES	Department of Education and Science
DLC	Desired Learning Competencies
DOST	Department of Science and Technology
DELSILIFE	Development of a Coordinated Educational System for Improving the Quality of Life of the Rural Poor Through Self Reliance
EDCOM	The Congressional Commission on Education
INNOTECH	Regional Center for Educational Innovation and Technology
ISMED	Institute for Science and Mathematics Education Development
MCTP	Mathematics Curriculum and Teaching Project
M^2IP	Michigan Mathematics Inservice Project
MSP	Mathematics Society of the Philippines
MTAP	Mathematics Teachers Association of the Philippines
NCR	National Capital Region
NCTM	National Council of Teachers of Mathematics
NIC	Newly-Industrialized Country
NSEC	New Secondary Education Curriculum

NUD•IST	Non-numerical Unstructured Data. Indexing Searching Theorising
OHP	Overhead Projector
PASMEP	Philippines-Australia Science and Mathematics Education Project
PHEM	Physical and Health Education and Music
PNG	Papua New Guinea
RECSAM	Regional Centre for Science and Mathematics
RLS	Regional Leader School
SEDP	Secondary Education Development Project
SY	School Year
THE	Technology and Home Economics
TRM	Teachers Resource Materials
UP	University of the Philippines

CHAPTER 1:

Introduction

This study was aimed at evaluating a model for a school-based professional development program for secondary mathematics teachers in the Philippines. The study involved teachers in one school as they participated in an action research cycle of professional development. The effectiveness of this approach in terms of teachers' professional growth is reported. Constraints related to the use of this approach in the Philippines have been identified.

Background to the study

Improving the quality of mathematics teaching and learning is a universal goal in mathematics education. To attain this goal, the teachers' role is an important factor. Pascua (1993) emphasized the importance of the teachers' role when she described the situation of secondary mathematics education in the Philippines. She indicated that it was extremely important to consider the role of a teacher as an agent of change and development. The National Council of Teachers of Mathematics (NCTM) (1989) observed that teachers are key figures who are able to change the ways in which mathematics is taught and learned in schools. However, NCTM (1989) acknowledged that the degree to which teachers can effect change is mostly based on their experiences, knowledge of mathematics, students and pedagogy, and also on their awareness of educational reforms. The challenge for teachers is to acknowledge that in education, the process of change is continuous and that being a teacher involves a continuous process of learning. This process of professional growth is enhanced by teachers' involvement in professional development programs.

Different models of professional development for teachers have been explored by researchers. These have involved inservice training such as the study by Borchers, Gail and Enochs (1992). A part of their study was the training of teachers in the use of computers in science teaching. They found that, after the training, the main change in the teachers involved the use of computers in their teaching and enhancement of their ability to use the computers. Lucas, Swinson and Tulip (1993) also conducted a study on inservice training for a group of lecturers to strengthen their competence and confidence in pedagogical skills and curriculum development. For a significant number of lecturers, these authors found that the goals for the course were achieved and the ideas and strategies introduced continued to influence lecturers' performance after a period of three months. Other forms of professional development studies were conducted such as the study by Sparks (1986) on the effectiveness of alternative training activities in changing teaching practices. Three groups of teachers participated and she found that the group that engaged in peer observation appeared to be a more effective training activity than the groups where no extra activity was given and where a trainer was provided. Chapman (1993) carried out an investigation on teachers engaging in autobiographical stories as a means of professional development. One of her findings was that the teachers became more reflective in their teaching. It appeared that under certain conditions, models employed by these researchers resulted in desirable changes to the teaching and learning of mathematics.

There are authors who recognized the power of school-based professional development. Mousley (1992) revealed that that a school-based professional development model was widely used in Australasia by teachers who would have an important role to play in the development of understanding in the teaching process. Castle and Aichele (1994) stressed that this form of professional development can result in a meaningful and long-lasting change in teachers' approaches to teaching.

Cohen and Manion (1994) suggested that action research is appropriate for the personal development of teachers especially when it is directed towards improving teaching skills, developing new ways of learning and increasing teachers' powers of analysis or heightening their self-awareness. Action research was described by Kemmis and McTaggart (1988) as a collaborative effort by teachers to conduct an inquiry about their own practice.

The use of action research as a form of professional development of mathematics teachers has shown positive results with respect to desired changes in school. Ellerton, Clements and Skehan (1989) found that the teachers involved in their study gained confidence and became more reflective mathematics teachers. The team of Herrington, Sparrow and Swan (1995) also carried out an action research project. They found that it was more productive for teachers who were willing to be involved than for those who attended because it was required by an external authority. Based on the claims of these authors, it is apparent that action research has much to offer for promoting change in school mathematics. However, there were also researchers who were critical of the use of action research for professional development of teachers. Johnston (1994) argued that action research has not been a natural process for teachers. For example, in action research, the participants are required to reflect on their performance and it is argued that this is not a natural process. In the case study of Stevenson (1991), he found that teachers who did action research as part of their graduate course, used a technical approach to their research despite the emancipatory conception of action research that was suggested in their course. Other than being part of a course, it also appeared that action research studies were feasible because funding was available, for example, in the Ellerton et al. (1989) study. Furthermore, action research studies reported in the literature have been carried out predominantly in countries that were different in terms of the educational context from the Philippines. As a consequence of all these results and issues concerning the use of action research for professional development of teachers, the benefits of this approach in countries such as the Philippines warrant further research.

In the Philippines, many forms of professional development programs for secondary mathematics teachers have been conducted, especially over the past eight years. This can be attributed to major changes made by the Department of Education Culture and Sports (DECS) in the secondary curriculum known as the New Secondary Education Curriculum (NSEC). The NSEC was fully implemented in June 1992 under the Secondary Education Development Program (SEDP).

Commenting on the significance of these professional development programs, Pascua (1993) remarked that "much time, effort and money has been spent on training teachers for different purposes—for teachers of the trial classes, for trainers who will handle the training of others and for those who will teach in schools" (p. 169). An example of such training programs is the training of trainers for mathematics, carried out over a period of one month at the University of the Philippines Institute for Science and Mathematics Education Development (UPISMED)—the university chosen by DECS as the Center for Excellence (CENTREX) for secondary science and mathematics.

The DECS and the Department of Science and Technology (DOST) also continued to conduct training and workshops which were attended by teachers from the secondary schools and the teacher training institutes. The purpose of these workshops were to help in attaining the target of the Bureau of Secondary Education (BSE) to raise the level of student performance in science and mathematics by at least 60% (Llagas, 1994). This author went on to say that to meet this target, professional development programs for teachers should be an integral part of the activity in the upgrading of teachers' competency. Furthermore, she said that this activity should continue "even when the financial, managerial and technical assistance of the external agency or institution is withdrawn" (Llagas, 1994, p. 1). The use of school-based professional development programs seems to be implied by this statement. This is not the usual form of most professional development programs in the Philippines. The common forms were seminars or workshops which were usually externally mandated and rarely school-based. The seminars and workshops usually required teachers to attend designated training centers which entailed time away from school and expenses such as transportation costs. While benefits from inservice training of this kind may exist, it appears that some writers are questioning such approaches. Castle and Aichele (1994) said that this approach to professional development does not result in qualitative change. Furthermore, Fullan (1991) commented that the needs of teachers are not properly addressed because of the lack of consultation with teachers. Alternative approaches to professional development which would result in documented benefits and which are less costly in terms of valuable resources may better suit the needs of the Philippines. In this context, an investigation was needed to evaluate the effectiveness of action research as a school-based professional development program.

Significance of the study

In the Philippines, DOST released the Science and Technology Education Plan in 1993 (DOST, 1993). It was stated that one of DOST's indicators in assessing the impact of its programs and projects from 1995 to 1998 was the number of mathematics and science teachers who had been involved in action research projects. Although teachers have claimed to have participated in action research projects (for example, Reyna, 1994), there was no indication that these projects have involved a study in changes to teaching practices and carried out in cycles. In addition, in the context of the Philippines, many factors need to be taken into account when conducting action research programs. The situation, in terms of educational context, is significantly different from those countries which have had a history of involvement in action research. Green (1992), Pilor (1993) and Ulep (1993) described some of the issues facing the teaching of mathematics in the Philippines. These descriptions need to be taken into account when action research is done in the country. These authors identified areas of concern including (a) teachers' mastery of subject matter, (b) large class sizes, which range from 36 to 92, (c) teachers' heavy workload, (d) lack of opportunities for inservice education (mainly due to geographic location), and (e) lack of facilities such as libraries and equipment for laboratory use. Moreover, mathematics is taught in English, which is not the teachers' and students' first language, and so both teachers and students may not be fluent in their use of English.

Dissatisfaction with the state of education in the Philippines, specifically in primary and secondary school mathematics and science is still being made known to the public through the newspapers in articles such as "More math, science teachers" (Castro, 1997) and "RP gets poor rating in math science tests" (Tarcelo, 1997). In these articles, it was stated that only 20% of mathematics teachers are qualified to teach mathematics. However, DECS' "records show that as of SY 1996-1997 only 8.14% of our teachers [in Philippine secondary schools] are teaching mathematics and are assumed to be major in mathematics" (Office of Planning Service, 1997). This could be interpreted to mean that since there are eight subject areas in secondary schools, each area should have a share of approximately 12.5% of the total number of teachers. This would further mean that about 65% of secondary mathematics teachers were majors in mathematics. Comparing the figure given by the newspaper article which is 20% and this 65% from DECS, it would appear that even those who were majors in mathematics were not always considered as qualified to teach mathematics by the DOST. It was not surprising that this fact caused the DOST secretary to stress the urgent need for the professional development of these teachers (Tarcelo, 1997). This need for teachers' professional upgrading was also mentioned by the DECS secretary (Castro, 1996). He said that he expected teachers to become effective agents of change in the community through revitalization of a school-based structure. In this context, this study appears to be very significant as it could provide DOST and DECS in particular, information regarding the effectiveness of a particular approach of professional development that is innovative in the context of the Philippines. Furthermore, researchers and designers of professional development programs, specifically in the area of mathematics education, may gain further insights into this form of professional development. As the research was school-based, the program should benefit teachers in the Philippines through their active involvement in action research programs, especially those who have fewer opportunities for inservice education because of their school's geographic location. In particular, this study will assist ISMED in its design of professional development programs for mathematics teachers throughout the Philippines.

Purpose of the study

The purpose of this study was to evaluate and document the use of action research as a school-based professional development model for secondary school mathematics teachers in the Philippines. In particular the study aimed to:

- identify the professional development needs of a group of secondary mathematics teachers related to the way mathematics is taught; and
- develop and implement an action research model and evaluate its effectiveness as a school-based professional development activity for a group of secondary mathematics teachers in the Philippines.

Research questions

1. What are the professional development needs of a sample of secondary mathematics teachers in the Philippines?
2. How effective is action research as a school-based professional development model for a group of secondary mathematics teachers in the Philippines?
   (i) What are its effects on the teacher's pedagogical knowledge?
   (ii) How are teachers' beliefs and practices affected by their participation in this professional development?

3. What are the constraints for using action research in the professional development of teachers? Considering these constraints, what changes, if any, in the usual process of action research can be made to suit the Philippine situation?

Organization of the thesis

This thesis is organized in seven chapters. Chapter 1 gives an introduction to the study by considering the background, significance, purpose, and the research questions. Chapter 2 reviews the previous findings related to professional development models and their evaluation. Chapter 3 discusses the pilot study which was conducted to determine the feasibility of some of the instruments to be used in the main study. Chapters 4 and 5 answer the first and the second research questions respectively. Chapter 4 focuses on the assessment of teachers' needs, while chapter 5 discusses the effectiveness of the action research program. Both chapters include a description of the participants involved, the design, the instruments used, procedure, analysis and discussions. Chapter 6 considers the third research questions. This chapter identifies the constraints faced by the teachers as they attempted to make changes on their teaching of mathematics. Chapter 7 presents and discusses the conclusions, limitations and implications of this study to mathematics teaching, professional development and for further research.

CHAPTER 2

Review of Literature

Introduction

This chapter reviews the literature in three main areas: mathematics education in the Philippines, models of professional development, and the evaluation of professional development programs.

Secondary mathematics education in the Philippines

This section discusses the secondary mathematics education in the Philippines by firstly considering the basic information about the country, then, secondly, secondary education and in particular the secondary school mathematics curriculum.

Information about the Philippines

The Philippines consists of 7 107 islands and has a land area of 300 000 square kilometres. These islands are divided into three main areas: Luzon, Visayas and Mindanao (Refer to Appendix A for the map). These areas are divided politically into fifteen regions. Luzon is the major northern island where Manila, the capital of the Philippines, is found. Luzon and its neighboring islands are divided into seven regions: regions 1 to 5, the Cordillera

Autonomous Region (CAR) and the National Capital Region (NCR). The NCR is the metropolitan district of Manila commonly referred to as Metro Manila and comprises the city of Manila and its neighboring cities and municipalities. Metro Manila is the center for government offices, commerce, industry and education. The Visayas is the middle group of islands where regions 6 to 8 are found. Mindanao is the southernmost group of islands where regions 9 to 12 and the newly formed Autonomous Region of Muslim Mindanao (ARMM) are situated.

Philippines has a population of 68 million. There are 11 languages and 87 dialects in the country (Malacañang, 1997a) . The national language is Filipino which is primarily based on the Tagalog language, a language spoken by most people of regions 3, 4 and NCR. Filipino and English are the official languages.

Secondary education in the Philippines

The primary and secondary school systems in the Philippines are centralized and managed by the Department of Education Culture and Sports (DECS). This department is headed by the Secretary of Education whose office is in Metro Manila. In each region of the country, a director is assigned the responsibility for all aspects of public education in that region. Each region is further divided into divisions and each division is headed by a superintendent. In a secondary school, the head of school is the principal with a department head responsible for each subject area.

The formal education system in the Philippines covers fourteen years. Primary education is six years (ages 7-12), secondary education is four years (ages 13-16) and a Bachelor's degree requires at least four years (ages 17 and over). Primary and secondary education are compulsary and free in government schools.

Secondary schools are classified as general secondary and special secondary schools. Both types have a general education program to equip students for either post-secondary or tertiary schooling or work. The only difference between the two types of schools is in their curriculum offerings. In special secondary schools like science high schools, more subjects are offered in addition to those offered in general secondary schools.

In the school year 1995-1996, the school year when the data gathering for this study was conducted, there were 4 872 860 secondary school students and 130 818 secondary school teachers (Department of Education Culture and Sports [DECS], 1997).

The New Secondary Education Curriculum (NSEC) is a curriculum which is "aimed at improving the quality of secondary education through curriculum development, staff development and physical facilities development" (EDCOM, 1993, p. 53). This curriculum contains eight subject areas namely: mathematics, science and technology, technology and home economics (THE), English, Filipino, *araling panlipunan* (social studies), physical and health education and music (PHEM), and values education. The first four subjects are taught in English and the rest, in Filipino. Except

THE and science and technology, all areas are taught once a day for a 40-minute period, five days a week, from June to March. Science and technology has a daily time allotment of 80 minutes, while THE has 60 minutes in first and second years and 80 minutes for third and fourth years.

Secondary mathematics education curriculum

The mathematics curriculum aims to contribute to the society. It has a design to provide students with knowledge, skills and attitudes necessary for them to participate actively as informed citizens in society. In particular, this curriculum is aimed at "cultivating basic skills of numeracy, developing logical and creative thinking skills and problem solving in daily life situations and related fields, together with reinforcing general skills of communication, manipulation of tools and equipment, social interaction and valuing" (Pascua, 1993, p. 166).

In this new mathematics curriculum, all students from first year to fourth year engage in one set of curricular offerings. Students have no options for elective subjects. Elective subjects, such as statistics, offered in the 1973 Revised Curriculum have been integrated in the present curriculum. Now, key concepts in each area of mathematics are developed gradually over the four years. This means that algebra, geometry, statistics are revisited each year. This is one of the main changes to that of the previous curriculum where mathematics was studied as a sequence of areas. The concepts learned in every year level have been arranged in a progressive order as shown in Table 1 (adapted from Pascua, 1993).

Table 1: The high school mathematics scope and sequence chart

First year mathematics	Second year mathematics
Fractions and decimals Percent and ratios Plane figures Measurement Tables and graphs Algebraic expressions Mathematical sentences	Algebraic expressions and operations Sentences in two variables Linear relationships Systems of linear equations and inequalities Some geometric relations Triangle congruence Quadrilaterals Measures in statistics
Third year mathematics	**Fourth year mathematics**
Exponents Radicals Special products and factors Rational expressions Quadratic equations Quadratic functions Variation Similarity Sequences and series Percentiles and quartiles	Exponential functions Logarithmic functions Polynomial functions Circles Circular functions Counting principles, permutation, combination and probability Linear correlation Complex numbers Computer literacy

The topics listed in every year level are ordered in the way in which these would be taught in class. However, Ulep (1993) reported that for a particular year level, many teachers were unable to teach all these topics for they tended to spend more time with topics they were more confident in teaching. In the old curriculum this would have a minimal effect because, not completing, say, geometry in Third Year did not affect the teaching of algebra in the Fourth Year. However, in the current curriculum, this procedure of failing to teach difficult topics can be problematic because the topics are revisited every year with increasing depths and difficulty.

How mathematics is generally taught in class was described by Pascua (1993) as "extensive teacher-directed explaining and questioning in a whole group setting" (p. 171). Moreover, this author said that the use of group work was done superficially as teachers remarked that it was taking too much time and often required the preparation of materials. Ulep (1993) also described how secondary mathematics is taught in school, particularly regarding the questions asked by teachers. She said that teachers' questions often required short and definite answers and were based mostly on knowledge, comprehension and application levels. Teachers would seldom present challenging problems for students to solve, rather they would give exercises. The teacher then asked students to go to the board and write their answers to these exercises. She also remarked that teachers did not encourage students to ask questions.

The effective use of resources such as low-cost visual aids, calculators and computers in the mathematics classroom is expected in the present curriculum (Pilor, 1993). Some teachers had made devices like spinners and geoboards and were observed to be slowly introducing them into their classrooms (Pascua, 1993). However, Pascua also observed that the use of calculators was still limited as most students were not able to buy them. In terms of computers, she said that only a few of the public schools and relatively more of the private schools have them for use in teaching. The lack of instructional materials was also mentioned by Ulep (1993). She said that, in many cases, the textbook and the teacher's guide were the only available classroom resources. This could be the reason why Green (1992) observed that even the best teachers just worked through the textbook and were following the contents of the book meticulously.

In the NSEC, students' progress was evaluated according to DECS Order No. 66 based on the following: (a) written output such as quizzes, unit tests and periodic tests, 40%, (b) oral participation and projects, 50% and (c) behavior, 10% (EDCOM, 1993). Although, it appeared that students' assessment was based on different categories, Pascua (1993) and Ulep (1993) noted that the assessments used were mainly tests using paper and pencil.

Models of professional development

It can be argued that the impetus for change in mathematics education is a global phenomena. Many countries have documented the need for reforms. Reports such as the Mathematics Counts (Department of Education and Science, 1982) in Britain and the Curriculum and Evaluation Standards (NCTM, 1989) in the United States and the resource materials of the Mathematics Curriculum and Teaching Project (MCTP) (Lovitt & Clarke, 1988) developed in Australia have been prominent in the reform movement. In the Philippines, the implementation of the New Secondary Education Curriculum (EDCOM, 1993) is also expected to result in significant changes in the teaching and learning of mathematics.

To prepare teachers to accommodate educational change, effective professional development is needed (Hyde, 1989). The role of the teachers together with the form of professional development appear to be critical aspects in the process of change. In the Philippines, Pascua (1993) made the comment that " the role of the teacher as an agent of change and development is extremely vital" (p. 167). She also said that a well-designed and well-managed inservice program is also a key for significant change to occur.

In the following section, a discussion on the different models of professional development will be considered, with a focus on teachers' involvement in such forms of professional development. Discussions will also center on action research as a form of professional development as well as the other types of professional development programs conducted in the Philippines.

The different models of professional development

Professional development can take many forms. The MCTP used a classification scheme which they claimed to be based on teachers' practical experiences and on theoretical perspectives (Lovitt, Stephens, Clarke & Romberg, 1990; Owen, Johnson, Clarke, Lovitt & Morony, 1988). They enumerated eight professional development models: structured course, sandwich model, preservice course, postal model, school cluster group, activity documentation, in-school intensive and peer tutoring. In a structured course, teachers attend an organized sequential course on a regular basis over a period of time. The sandwich model requires teachers to attend two sessions of workshops scheduled apart, with trialing of activities in class between these two sessions. In the preservice model, student teachers try activities while in school in the presence of supervising teachers. To support teachers' professional development in remote places, comment that " the role of the teacher as an agent of change and development is extremely vital" (p. 167). She also said that a well-designed and well-managed inservice program is also a key for significant change to occur.

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Clarke and Hollingsworth (1994) classified professional development according to the change perspectives. They said that change could be something that (a) is done to the teachers such as training programs, (b) is experienced by the teachers such as a response to a change in class size, (c) teachers do with a purpose, either to themselves, to their environment or acting as agents for others and (d) is inherent to the professional development activity, that is, teachers change inevitably through the activity. It appears that these authors encouraged the adoption of a growth perspective on teacher change and professional development activities because it recognized teachers having control of their learning.

The scheme of Sparks and Loucks-Horsley (1990) described models of professional development that were based on theoretical and research underpinnings. These categories included: individually guided staff development, observation and assessment, training, development and improvement process, and inquiry. In the individually guided staff development model, teachers select their own learning goals and activities. The observation and assessment model includes a focused observation then an analysis of the data. In the training model, teachers acquire knowledge or skills through teaching from an expert in the field. Involvement of teachers in the curriculum development or school improvement process is considered another model for professional development. Teachers would be required to identify a problem or a need, develop an action plan, implement the plan then assess the outcome. This would be similar to the inquiry model, except that the latter requires the teachers to make changes in their teaching based on their interpretation of the data and preferably in longer periods to give time for more trials. It is apparent from the different classification schemes that many categories are similar in nature but are given different names. For example, the activity documentation model of Owen et al. (1988) is similar to the development and improvement process model of Sparks and Loucks-Horsely (1990). What follows is a review of projects associated with different professional development programs that are used in mathematics education.

Sparks and Loucks-Horsley (1990) said that in the minds of many educators, staff development and training are synonymous. These were sessions which teachers would attend with the expert controlling the content and flow of the activities. An example of this type of professional development program is the first phase of the Michigan Mathematics Inservice Project (known as M^2IP) of Laing and Meyer (1994). Here, 40 hours of an inservice program was conducted to familiarize teachers with teaching principles in mathematics. They found that this program resulted in the professional growth of participating teachers. Teachers considered their involvement to be helpful in the area of preparing better lessons and getting to like mathematics more. However, it required coordination of a variety of funding sources.

In the Philippines, training programs for secondary school teachers have been conducted extensively since 1988, the year before the start of the NSEC. The teacher training programs were conducted to ensure that the implementation and changes that would take place in mathematics teaching would be successful (Pascua, 1993). In these training programs, selected teachers attended for a month to strengthen their knowledge of mathematics, enhance their competence in different teaching strategies and become better prepared to conduct similar mass training in their respective regions. Pascua (1993) indicated that for many teachers these programs also served as a refresher course on mathematics concepts that they had not been teaching for quite some time.

There are also professional development models that reflect the ability of teachers to select and design their own workshop activities alongside the assistance provided by the project staff. An example of this type of professional development was the Xavier School Workshop (ISMED, 1993; 1994). Teachers attended a two-week workshop where they identified mathematical content and teaching strategies suited to the needs of their students. Teachers found this program productive as it changed the teaching practices of participants (ISMED, 1994). As a result, a similar workshop was conducted a year later on instructional materials development. In the USA, a curriculum approach for developing elementary school children's understanding of mathematics, the Cognitively Guided Instruction (CGI), included significant professional development for participating teachers. Chambers and Hankes (1994) indicated that this model of professional development required teachers to choose their own activities. In returning to their respective schools, the participating teachers designed their own classroom activities based on their knowledge of how children learn mathematics and on what they learned from the six-day workshop. It was mentioned in this study that the teachers received graduate credit and financial support for participating in the program. The authors claimed that there was a dramatic change in classroom teaching.

Other professional development models have been evaluated. Sparks (1986) completed a study on the relationship between types of professional development activities and changes in teaching behavior. Three groups of teachers participated in the study. They all attended five workshops on effective teaching. However, each group participated in different sets of training activities. The first group were not given extra activities, the second group used peer observation and the third group used trainer-provided coaching. The author found that peer observation appeared to be effective in terms of changes in teaching and also cost effectiveness. This 'observation and assessment' type of professional development was also used in the Philippines for a large-scale training of teachers (Philippines-Australia Science and Mathematics Education Project [PASMEP], 1990). Two days out of a two-week workshop was allocated to micro-teaching sessions. This activity was considered by the participants as invaluable because it gave them immediate feedback and an experience on teaching teachers. Some of the teachers involved in this professional development were also selected to participate in curriculum development workshops preparing resource materials specifically for teachers who were not mathematics majors (PASMEP, 1991; 1992). These workshops, which had support and funding from PASMEP, required teachers to be away from their classrooms. For the teachers involved in these curriculum development workshops, it was another form of professional development activity.

This form of professional development, which involved teachers in a curriculum development project, was also used in Papua New Guinea (PNG) (Lucas et al., 1993). Here, a group of mathematics lecturers participated in a workshop to develop a mathematics curriculum for their particular college. The authors indicated that this form of curriculum development was effective in achieving the objectives of the workshop. They found that after three months, a significant number of lecturers used the ideas and strategies introduced in the workshop.

There are other professional development programs which required teachers to undertake a form of inquiry. The case study of Ellerton, Clements and Skehan (1989) involving eight teachers using action research is an example of this model. The authors said that, although at the start of the project teachers only had the vaguest idea of action research, in the end it was found to be effective because teachers considered this to be the most useful and had the most lasting effect of all the professional development programs in which they had been involved. In addition, the authors also mentioned that the teachers were freed from their class for the meetings and substitute teachers were employed out of the funds from the project. Herrington, Sparrow and Swan (1995) also carried out research with groups of teachers from three different school settings. The teachers undertook an inquiry into their teaching of mathematics. The teachers identified their problems and priorities, planned an approach to solving their identified problems, carried out the plans and reflected on the success of the approaches ready for further planning. These three researchers observed that the classroom teachers who volunteered to participate in the study were enthusiastic and willing to make changes to their teaching.

These different models of professional development are summarized in Table 2 using the categories of Sparks and Loucks-Horsley (1990).

Table 2: Models of Professional Development

Model of Professional Development	Description	Examples: Philippines	Examples: Other Countries
1. Training	Teachers acquire knowledge and skills through instruction	Trainers Training Program (ISMED, 1991)	The M²IP (Laing and Meyer, 1994)
2. Individually Guided Staff Development	Teachers develop their own units based on their needs with the assistance of the project staff.	Xavier School Workshops (ISMED, 1994)	CGI (Chambers and Hanks, 1994)
3. Observation and Assessment	Teachers collect and assess instructional performance through observation, coaching and performance evaluation.	PASMEP Follow-Up Workshops (PASMEP, 1991)	Effects of Alternative Trainings (Sparks, 1986)
4. Involvement in a Development or Improvement Process	Teachers are involved in curriculum development or improvement projects, from which in turn they benefit in terms of their own professional development.	Curriculum Development Workshops (PASMEP, 1992)	PNG Workshops (Lucas, 1993)
5. Inquiry	Teachers identify an area of interest, collect data and make changes in their teaching based on their interpretation of the data.	Undocumented	School-based Professional Development (Herrington, Sparrow & Swan, 1995)

It is apparent from the review that there is a variety of professional development models from which to choose, but which approach is the best is still an open question. Looking at the different models used by the researchers, it appears that time, funding and motivation to participate are critical factors to be considered when planning teachers' professional growth.

In his review of inservice education over a period of ten years, Fullan (1991) listed several reasons for failure of many professional development programs. One of the reasons is that the topics addressed in the program are selected by other people such as school administrators, without consulting the teachers who are required to participate. This results in the needs and concerns of the participants being rarely or properly addressed. House (1994) confirmed that this occurs when change is sought in a top-down manner without the significant involvement of concerned teachers. Most models in Table 2 have this design and also overemphasize the deficiency of teachers' skills and knowledge.

Castle and Aichele (1994) commented on professional development that is externally mandated. They said that although the professional development is well intended, it usually fails because it does not result in development as a qualitative change. They believed that professional knowledge cannot be transferred, but that it is in fact constructed by the teachers. In a study of alternative training activities by Sparks (1986), the author indicated that teachers can learn from each other. This was also the findings of Holly and McLoughlin (1989). They said that many teachers consider their colleagues to be the source of ideas that are most helpful for their teaching.

Mousley (1992) noted that professional development programs that involve one-shot training do little to help teachers develop the interpersonal skills and attitudes they needed to cope with the complex and shifting relationships within schools. The 'one-shot' approach was also mentioned by Lovitt, et al. (1990) as not effective in leading to long lasting change. The team of Borchers, Gail and Enochs (1992) drew a similar conclusion on this issue. They found that one-shot workshops are not effective in changing teachers' behaviors and beliefs. They found this during a study on changes in teachers' behavior and beliefs from rural schools as they participated in a program on the use of computers in science teaching.

All comments of these different authors about the effectiveness of professional development programs are neatly summarized by Lovitt et al. (1990). They enumerated nine key features of an effective professional development program:

- address issues of concern recognized by the teachers themselves;
- be as close as possible to the teacher's working environment;
- take place over an extended period of time;
- have the support of both teachers and the school administration;
- provide opportunities for reflection and feedback;
- enable participating teachers to feel a substantial degree of ownership;
- involve a conscious commitment on the part of the teacher;
- involved groups of teachers rather than individuals from schools;
- use the services of a consultant or critical friend. (p. 234)

Action research seems to fit well into this description. Thus, a more detailed discussion of this form of professional development follows.

Action research as a form of professional development

Teachers inquiring into their own practices of teaching was categorized by Richardson (1994) as either: formal research or practical inquiry. Formal research, as done by practitioners and researchers, contributes to an established and general knowledge base, whereas inquiry, done mainly by practitioners, improves knowledge. He indicated that action research was an effective approach to practical inquiry.

Many definitions of action research can be gathered from several authors. Kemmis and McTaggart (1988) defined action research as a "collective self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out" (p. 5). These authors pointed out that participants involved in action research are expected to carry out a cycle of planning, acting, observing and reflecting on activities in a collaborative manner. Elliot (1991), defined it as a "study of a social interaction with a view to improving the quality of action within it" (p. 69). This author also mentioned the different activities to be carried out in action research. These are: identifying an initial idea, reconnaissance, constructing a general plan, developing the next action steps and implementing the next action steps. Dick (1994) referred to action research as an activity to produce both 'change' (action) and 'understanding' (research). He explained that action research should be critically reflective within a cyclic process in order to attain understanding and change in a participatory mode. Grundy (1995) identified three features that distinguish action research from other forms of action. She said that the first feature indicates that the action should be strategic in bringing about change, second, the practitioners should be involved as participants and last, a spiral of cycles should be incorporated. Considering the different descriptions of action research, several themes appeared: identifying a change to improve current practices, collaboration through participation, and a spiral of actions.

Grundy (1982) explained that the degree of involvement of the participants in action research would vary depending upon which of the three modes is preferred by them. She said that if they adopt the *technical* action research mode, then it would be the facilitator's idea which directs the program. When they opt for the *practical* action research mode, they are expected to improve their practice through the application of personal wisdom. When they choose to use the *emancipatory* action research mode, they focus not only on their professional practice, but also on the theoretical and organizational structures and the social relations which surround them.

In understanding the potentials of action research, Noffke (1997) said that it is important to look at its different dimensions: professional, personal and political. In the professional dimension, this author indicated that when action research is used as a means of professional development, it is important to recognize whose needs are being considered. In the personal dimension, areas such as the enhancement of knowledge and understanding one's own practice should be considered. Finally, in the political dimension, issues such as democracy and social justice should be highlighted.

The power of action research when used in schools has been argued by several authors. Cohen and Manion (1994) said that it was appropriate for teachers' enhancement of teaching skills, developing new ways of learning and increasing their power of analysis. Grundy (1995) argued that action research is indeed a powerful form of professional development. She affirmed that its power comes from the fact that the focus of inquiry and interest in action research is the participants' own practice. She further explained that factors such as hierarchy, experience, or other status conferring attributes are not privileged in action research because this kind of professional learning is a democratic form of work organization. In a study with group of teachers and students in New Zealand's secondary schools bilingual units, Knight (1991) found that action research had a significant potential in bilingual education. Another study using action research was conducted by Stevenson (1991). It was designed to engage inservice education students as inquirers into their own professional practices. The author said that professional development associated with action research usually resulted in supportive conditions because it required teachers to reflect systematically on their practices and to have extensive discussions with one another. Another benefit was that teachers who experienced action research became more flexible in their teaching, more open to new ideas and better problem solvers (Groarke cited in Oja & Smulyan, 1989). Based on these views, it is apparent that there are a number oi benefits to be obtained from action research, particularly in relation to teachers' professional growth.

Studies concerned with the effectiveness of action research on the professional development of mathematics teachers have been conducted by a number of researchers. Ellerton, Clements and Skehan (1989) undertook a study with a group of primary teachers in two schools. Teachers worked in pairs, one teacher observing the class of the other. After the observation, the pair discussed what happened and made suggestions for the next cycle. The authors found that the teachers involved in action research gained confidence and became more reflective in their teaching of mathematics. Huat et al. (1991) and staff from the Regional Centre for Science and Mathematics (RECSAM), together with a group of Malaysian teachers, claimed that their action research project resulted in significant professional growth to the participants. The participants focused on the constructivist ideas in science and mathematics education. These teachers were so involved in their participation that for them it was natural and spontaneous. In tertiary teaching, the use of action research was explored by Schratz (1993). He found that other faculty members in a university could be influenced to participate which resulted in their own professional development. He indicated the possibility of 'ripple effect' where more teachers could be attracted into a project which in turn could facilitate their own professional development. Miller and Hunt (1994) used action research to study the use of students' writing in mathematics. They found their experience to be rewarding and enjoyable and most of all claimed to have learned a lot from the experience. As a consequence, they felt that a change had occurred in their teaching practices that was more aligned with current reforms in mathematics teaching. Herrington et al. (1995) conducted an action research project with mathematics teachers in three school-based settings. They found that this form of professional development was more beneficial to those who showed a willingness to be involved.

Although it appeared that action research offered benefits to the professional growth of teachers, there were also researchers who questioned the use of action research as a form of professional development. Johnston (1994) acknowledged that although teachers' involvement in action research may result in significant changes to their teaching practices, she doubted if action research was really a 'natural' process for teachers. She drew this conclusion from the belief that action research was rarely undertaken by teachers without external intervention such as funding or as a course requirement. The funding issue for action research was also referred to in other studies (for example, Ellerton et al., 1989). As a course requirement, Stevenson (1991) studied a group of teachers who did action research as part of their graduate course to examine claims that action research improves teachers' understanding of their own practices. He found that despite the suggestions that were embedded in the structure of the course requiring students to engage in an emancipatory form of action research, teachers still opted to do the technical orientation. This was also the comment of Herrington et al. (1995) when they said that technical action research was the paradigm most often used by the researchers.

This review found that action research as a form of professional development for teachers has a lot to offer to enhance teachers' professional growth. However, there were also issues that needed to be considered such as the preparedness of teachers to be involved with action research and the context in which the research takes place. Particular types of professional development may be suited or constrained by the needs of particular countries. However, Clements and Ellerton (1996) said that throughout the Asia-Pacific region, it was important to employ action research methodologies in mathematics education. In the next section, various forms of professional development conducted in the Philippines will be discussed.

Professional development programs in the Philippines

In Table 2, examples of professional development programs that were conducted in the Philippines were given. In this section, a review of these professional development programs will be discussed. The discussion will be divided into three main areas depending on the location of the change initiative: first, training programs, second, workshops and third, action research. The training programs here refer to the professional development programs in which teachers acquire knowledge and skills through instruction and the change initiative is external. Workshops include professional development programs in which teachers collaborate with a group and with a facilitator to acquire knowledge and skills and the change initiative could be internal or external. Action research refers to the involvement of teachers in a professional development program that involves changes to their teaching practices through a cyclic approach.

Training programs

A report from the Asia Pacific Economic Cooperation (APEC) showed that many types of inservice training were used for mathematics teachers, most often through the provision of courses, both long and short, and the circulation of resource material (Asia Pacific Economic Cooperation [APEC], 1994). Philippines, being a member country, was no different from this. From 1988 to 1992, inservice training for secondary school mathematics teachers has been conducted for the institutionalization of the SEDP and the development of the teacher competencies demanded by the NSEC (The Congressional Commission on Education [EDCOM], 1993). To achieve these objectives, DECS identified five national training centers in the country, each of called the Center for Excellence (CENTREX) and four regional training centers in every region called the Regional Leader Schools (RLS). UPISMED was chosen as the CENTREX for the sciences and mathematics. Thus, UPISMED became the venue for conducting inservice training for science and mathematics trainers. The trainers, who underwent the DECS selection process, were to be responsible for the training of teachers in their respective regions. In these training programs, the trainers, usually four mathematics teachers from every region for each year level of mathematics, attended training at ISMED during the long school holidays for at least four weeks. In addition, three-week programs were conducted for trainers from private schools. In the public school system, these four trainers then conducted 15 days of training in their respective regions held at the RLS. In this large scale training, about half of the time was used to discuss the content of mathematics for that particular year level and the remaining half to discuss the different strategies for teaching mathematics and to evaluate learning outcomes (EDCOM, 1993). In every year from 1989 to 1992, there were about 4 000 public secondary schools and about 1 500 private secondary schools whose teachers attended the training conducted by these trainers (Pascua, 1993). Teachers perceived the training to have helped them gain many teaching skills (Nguyen, 1992). There were teachers who considered these content topics as updating their current knowledge base, while for others they were relatively new areas (Ulep, 1993). This is understandable given that in 1991 only 54.67% of the mathematics teachers in the Philippines had completed their preservice education with a major in mathematics (EDCOM, 1993). Also, only 18% of the total number of units they took in their preservice education were in mathematics (Department of Science and Technology [DOST], 1993; Pascua, 1993). Furthermore, there were teachers who had been teaching only a single topic, say geometry, for all their teaching career. It is worth noting that , in the SEDP, the curriculum was not covered topic by topic but topics were integrated into every year level (Institute for Science and Mathematics Education Development [ISMED], 1988; 1989; 1990; 1991).

Other training programs were also conducted that were not as massive as those mentioned above. Examples of these were the DECS Integrated Scholarship Program in which selected teachers attended training for a month at the CENTREX. Another example was the training of teachers who handled the trialing of textbooks to be used for the SEDP. There were also training programs conducted by mathematics organizations such as the

Mathematics Society of the Philippines (MSP) and the Mathematics Teachers Association of the Philippines (MTAP). Some teachers also attended training programs for specific mathematics topics offered at ISMED and other universities.

In the review of the reports from these training programs and from personal communication with some of the participants who attended these training programs, there was no mention of involvement of teachers in the design of the training programs nor was their willingness to participate sought.

Workshops

Workshops for mathematics teachers were also conducted. An example of this was the Xavier School Workshops (ISMED, 1993; ISMED, 1994). Here, all secondary mathematics teachers from the school participated in workshops to develop their own curriculum based on the NSEC and on the needs of their students. In these workshops, different teaching strategies were discussed to assist these teachers implement their planned curriculum. Another example of a workshop where the participants were involved in planning the changes to be made in their teaching was the Curriculum Development Workshops (PASMEP, 1991; PASMEP, 1992). Two mathematics teachers from each region of the country participated in the development of materials initially intended for mathematics teachers who were not mathematics majors. In the preparation of these resource materials, the participants were involved in the trialing and revising of these materials in their respective regions. An analysis of these professional development programs indicated that, although it was not mentioned who initiated the conduct of these workshops, it was evident that there was an input from the participants on the directions the workshops would follow. The participants had to suggest the type and format of materials which they thought would be of most use to teachers.

Action research

A review of the literature on action research that was conducted in the Philippines showed that only a few had been documented. The earliest action research found was the study on the development of an effective learning system for the improvement of life called Project DELSILIFE, an acronym for the Development of a Coordinated Educational System for Improving the Quality of Life of the Rural Poor through Self-Reliance (Soriano cited in Boeren, 1992). This was conducted in the middle of the 1980s. This project developed an educational intervention system aimed at improving the quality of life of the rural poor through self-reliance (Boeren, 1992; Regional Center for Educational Innovation and Technology [INNOTECH], 1997). The participants were involved in a participatory, bottom-up approach to arrive at decisions and solutions to their own problems. They found that this project contributed to an increase in income levels, as well as broadened levels of leadership. Although, in the DELSILIFE process, the typical action research processes were not that clearly described, all the features of an action research were present.

In secondary education, particularly in science and mathematics, some attempts were made to undertake action research projects. When a group of secondary school head teachers attended a one-month workshop conducted by PASMEP, the teachers were required to develop a research proposal using action research focusing on the improvement of classroom teaching and learning (Matthews, 1993). In one of the issues of the PASMEP newsletter, abstracts of action research studies were featured. It included works of Micayabas (1994) and Villamayor (1994) who claimed to have used action research for the training needs of teachers. Micayabas (1994) undertook a survey of Physics teachers from Region 10 who participated in the SEDP training in 1992 to find out their needs, while Villamayor (1994) did a descriptive survey on the profile and training needs of secondary mathematics teachers in Region 10. Another action research study that was reported in the same issue of the PASMEP newsletter was the work of Reyna (1994) on the effect of small-group activity on the mathematics achievement of her students. In the school year 1991-1992, she conducted an experiment with two groups of her students on the topic on quadratic functions. One group of students was exposed to a small-group activity while the other group did not use the small-group activity. Of these three research, there was no indication of there being a spiral of cycles of planning, implementation, observation, reflection and revision of plans which characterize action research. In addition, there appeared to be no study of changes to teaching practices.

It appeared that in the Philippines, action research could be effective. One example was the DELSILIFE project where one of the results was the increase in the income level of the participants. In mathematics education, attempts were made by mathematics teachers to do action research with modifications from the generally accepted description of action research. There is a clear need to investigate whether action research, which focuses on improving secondary mathematics teachers' teaching practices, and using a spiral of actions could be successfully implemented in the Philippines.

Evaluating professional development programs

Determining the type and effectiveness of professional development programs is a critical issue. Pointers to the success of various models need to be considered. The comments of researchers (for example, Lovitt et al., 1990) about giving teachers a substantial degree of ownership in their own learning by allowing them to participate in the design or direction of the program should be taken into consideration when designing professional development programs.

Professional development programs can be evaluated by gathering information from a variety of sources. Guskey and Sparks (1991) suggested that programs should be evaluated in terms of their impact on three entities: the participants, the school organization and the students. The impact on participants and students was elaborated upon by Guskey (1986). He said that the major outcomes of staff development were changes in the classroom practices, beliefs and attitudes of teachers and the change in the learning outcomes of the students. Borchers, et al. (1992) evaluated their programs in terms of teachers' behaviours and beliefs. The Active and Reflective Teaching in Secondary Mathematics Project (Clarke & Peter, 1993) looked into the context, participation, implementation, satisfaction, change in teaching practices and student outcomes.

Similar indicators were used when the Junior Secondary Mathematics Resource School Project was evaluated (Clarke, Morony & Schmitt, 1994). In this study, the teachers' skills, practices and beliefs and the students' outcomes were monitored by the authors. It is noteworthy that beliefs and practices were considered in evaluating teacher outcomes, reflecting the views of Cobb, Wood and Yackel (1990) that teachers' beliefs and practices are dialectically related. Thompson (1992) reviewed ten studies on teachers' beliefs about mathematics and indicated that beliefs play a significant role in changing teaching approaches. She also noticed that most research on teachers' beliefs and conceptions were interpretive in nature and used a qualitative method of analysis. Furthermore, in evaluating professional development programs, especially if they are based on action research, the approach tends to be qualitative (Dick, 1993).

Summary

In this chapter, three main areas were covered in the review of literature. These were the secondary mathematics education in the Philippines, the different models of professional development and the evaluation of professional development programs.

The educational system in the Philippines is managed by the Department of Education Culture and Sports (DECS). The Bureau of Secondary Education (BSE) is the branch of DECS responsible for all aspects in secondary school matters. Secondary schooling, which is free in government schools, covers four years with students' ages ranging from 13 to 16 years. In the New Secondary Education Curriculum (NESC), students are required to take at least eight subject areas per school year.

With this new curriculum, the implementation of the teaching of mathematics was described by Pascua (1993) as teacher-centered in which teachers would usually ask questions for anyone in the whole class to answer. Group work was rarely and superficially attempted. Many resources were not available and teachers relied mostly on the textbook and the teacher's guide. Assessment of students' learning was mainly using pencil and paper tests.

Different forms of professional development were reviewed. The review was based on five categories: training, individually guided staff development, observation and assessment, involvement in a development or improvement process and inquiry. Action research as a form of professional development falls under the inquiry category. Grundy (1995) claimed that action research is a powerful form of professional development for it is the participants' own practices that are being investigated. Furthermore, she described this form of professional development model as learning which is democratic because it involves all types and levels of teachers as equals, with position and educational hierarchy being irrelevant.

It emerged from the literature on the professional development programs that were conducted in the Philippines that training programs and workshops were the common inservice programs used. These programs, which were mostly initiated by the school administrators, were usually held in certain venues which would involve transportation and accommodation costs. In terms of action research as a form of professional development model, the literature review showed that, in the Philippines, the generally accepted features of action research were modified. In mathematics education, there was no documented action research incorporating the use of collaboration, or spirals of cycles to bring about change. Since there was no documented action research in mathematics education involving these characteristics, an investigation into the effectiveness of this form of professional development was proposed.

The literature relating to the effectiveness of professional development programs, indicated three groups that should be considered in any evaluation: participants, students and school organization. Guskey (1986) said that the first two groups were the important ones to consider. However, considering the impact on teachers, which is the concern of this study, it was found that changes in teaching practices and beliefs were the main aspects assessed by researchers when determining the effectiveness of a particular professional development program.

CHAPTER 3

The Pilot Study

Purpose

A two-week pilot study was conducted in a Perth metropolitan secondary school to develop instruments for evaluating teachers' beliefs and practices that were to be used in the main study. Due to the differences in educational contexts, the focus was on the instruments to be used rather than the outcomes relating to the main study.

The participants

Three mathematics teachers from the school were asked to participate. All of them were experienced teachers with at least twenty years of teaching experience. One of the teachers was the department head. All teachers taught mathematics in at least three different year levels between Year 8 and Year 12.

Procedure

The mathematics department head of the chosen school was contacted by the principal supervisor of the researcher. The researcher then met the department head and was introduced to the other two participants. Three

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Procedure

The mathematics department head of the chosen school was contacted by the principal supervisor of the researcher. The researcher then met the department head and was introduced to the other two participants. Three days after the introductory meeting, another meeting was held to discuss the pilot study. A letter of consent (Appendix B) was signed by each participant and a time schedule for interviews and classroom observations was arranged.

Interviews with the teachers were carried out individually and in groups. These interviews focused on the changes that the participants would like to make to their teaching of mathematics, and their current practices and beliefs about teaching and learning of mathematics. The interview guides (Appendices C and D) were found to be appropriate for the pilot study. Observations of classes were conducted over a span of two weeks. Each of the teachers was observed in class by the researcher for at least two lessons, both in different year levels. The researcher wrote a portrayal of the lesson after each observation (refer to Appendix E). Notes of each interview and observation was recorded by the researcher. The results of the interviews and observations were summarized by the researcher and handed back to the teachers for further comments.

Results, analysis and discussions

This section will discuss three main areas based on the results of interviews and class observations with the three teachers: the changes that the participants would want to make to their mathematics teaching, the beliefs they held and lastly, their teaching practices.

Changes to teaching

The individual interviews revealed that the three teachers described their typical mathematics sessions as a presentation that involved students' participation through questioning and activities. This presentation would depend on the year level. When asked about the changes that they would like to make to what they normally did in teaching mathematics, all of them agreed on the need to vary their teaching strategies and one was even specific about the use of computers and multimedia. All of them were aware that there would be constraints if they were to implement these changes. One of them mentioned the presentation of the lesson to the class as being a personal constraint. She felt that she tended to move too fast in discussing a lesson. Another constraint that was mentioned concerned the school. Provision of equipment such as computers in classrooms along with the professional development of teachers on how to use them effectively was lacking. Nevertheless, they thought it would be possible to make these changes in the future, if the school system would allow them sufficient time to discuss the use of technology and to prepare relevant lessons. As far as computers in school was concerned, one teacher felt that computers could be acquired by raising money in the community.

On beliefs

The teachers' beliefs were gathered through interviews. These beliefs dealt with their views about mathematics, mathematics teaching and mathematics learning. The following answers illustrate some of their beliefs:

I love mathematics and I like students. About mathematics learning? To be mathematics literate, it's a God given gift! No matter how you work at it, if you're not good at it, that's it! Parents panic because of the perception that it is difficult to learn. (Anita)

Mathematics should be non-threatening and not necessarily with instant answers. On mathematics teaching and learning, there should be lots of time for hands on, but [there are also] so many constraints. The way I like it to be, does not always happen. (Jenny)

These teachers also believed that it was important to teach and learn mathematics seeing it vital for everyday life and for developing thinking abilities.

It's fun. Interesting. I don't know how they will cope without maths. Talking about money, in real life, it's important. It's very important. Children should be literate and [there's] no choice about it. (Jenny)

It is an important subject. There will be no science without mathematics. It develops logical reasoning. (Anita)

The teachers also believed that, for students to learn mathematics, students should be aware of the mathematical ideas in each year level and should know the different methods to solve problems and have the courage to do it. The teachers said that their students participate in class activities and that students participated more when technology, like graphic calculators, was used. Furthermore, when asked about what they thought most students would have in mind about their mathematics teachers, their responses included:

They relate the measure of their success in the subject to the teacher. If they're good at the subject, then the picture of the teacher is good. (Anita)

Strict, unapproachable. The students have great insecurities. (Jenny)

It appeared that teachers had different perceptions about what their student thought of them.

On teaching practices

Data gathered from class observations showed that these teachers used various teaching strategies. What was observed by the researcher appeared to reflect the beliefs given in the interviews. For example, one of these teachers believed that mathematics should be non-threatening and not necessarily with instant answers. In her class, she appeared to be calm and approachable. Students appeared to be comfortable to ask questions and request for clarifications. She gave students enough time to work on the problems.

In summary, through the interviews and class observations, it appeared that these teachers were using varied teaching strategies. However, they still felt a need to make changes in their teaching of mathematics, particularly in the use of technology. Different beliefs were also revealed during the interviews. For example, the teachers believed that mathematics was important because of its usefulness in daily life and that it should be taught and learned by all students.

Implications

The results of interviews and questionnaires formed the basis of the development of questionnaires and interviews that were to be used in the main study. However, it was found in this pilot study that not all of the questions could be answered by this group of teachers. Understandably, some of the questions were specifically related to teaching in the Philippines.

Note taking proved to be an unsatisfactory method as used in the pilot study. It became clear during the pilot study that a more reliable method of recording interviews and observations such as the use of audio or video recording equipment was needed to capture details of the comments made by the teachers.

The class observations revealed that teachers used different teaching strategies. However, the consistent application of these strategies could not be described as the observations were made on different year levels and groups of students. For the main study, it was felt that there should be continuous class observations of the same teacher in at least three consecutive sessions with a particular class.

Summary

Several conclusions were drawn from this pilot study such as the needs of teachers, their beliefs and teaching practices. However, the purpose of this pilot study was not to come up with a generalization about the needs, beliefs and practices of these teachers, but mainly to validate the instruments and methods for the proposed main study. It was found that a sample from the Philippines would have been better for the pilot study rather than a sample in Australia because some questions were relevant only to the Philippines context. However, the need for more reliable instruments such as audio and video recording was identified as well as the need to undertake continuous classroom observations.

On the whole, this pilot study was helpful in refining the questionnaires, interviews and procedures to be used in the main study. These refined questionnaires were used in the main study to answer the first research question on teachers' needs and are discussed in the next chapter.

CHAPTER 4

Assessment of Teachers' Needs

Introduction

This chapter will discuss the needs of secondary mathematics teachers in the Philippines as perceived by three distinct groups: secondary mathematics teachers, PASMEP teachers and department heads. This discussion addresses the first research question: What are the professional development needs of secondary mathematics teachers in the Philippines? It was expected that answers to this research question would be of use in the next stage of this study in assisting participants to conduct a program of action research.

The participants

The participants consisted of three different groups. The first group consisted of 114 secondary mathematics teachers, the second group of 18 PASMEP mathematics teachers and the third group of 17 mathematics department heads. The department heads who participated in this study were from schools with the PASMEP teachers. The participants were from all regions of the Philippines except for region 11 (see Appendix A for the map).

The 114 mathematics teachers were classified according to four categories as shown in Table 3. The type of school was classified as *PASMEP* or *non-PASMEP,* coded as P and NP respectively, depending on whether a PASMEP trained teacher taught at the school or not. The classification for the position of the teacher was based on the salary grade. This means that *Teacher 1,* coded as T1, had the lowest salary among the group and the *Master Teacher* had the highest salary. The year level category would identify which level of mathematics these teachers were assigned to teach. As examples, the *Second Year only* category, coded Y2, means that these teachers were teaching Year 2 mathematics while the *Combination* category, coded Co were teaching at least two year levels of mathematics. The number of years of teaching experience category was divided into eight groups with a range of five years for each group, except for the first and the last groups. Codes for all these categories are shown in Table 3. In addition, Appendix F lists all the codes used in this thesis.

Table 3: Details of Sample of Teachers Involved in Survey of Professional Development Needs of Secondary Mathematics Teachers

Categories		No. of teachers
School	PASMEP (P)	67
	Non-PASMEP (NP)	47
Position	Teacher 1 (T1)	55
	Teacher 2 (T2)	12
	Teacher 3 (T3)	9
	Master Teacher (MT)	10
	Not Specified (NS)	28
Year level	First Year only (Y1)	19
	Second Year only (Y2)	17
	Third Year only (Y3)	21
	Fourth Year only (Y4)	14
	Combination (Co)	41
	No Answer (NA)	2
Years of experience	0-5 (+0)	37
	6-10 (+5)	27
	11-15 (+10)	18
	16-20 (+15)	8
	21-25 (+20)	15
	26-30 (+25)	3
	31-35 (+30)	1
	No Answer (NA)	4

Design

A survey was conducted to assess the professional development needs of secondary mathematics teachers in the Philippines. Three sets of questionnaires were used, with one set for each of the three groups of participants. These questionnaires were posted to the principal of the schools with PASMEP teachers. The PASMEP teachers were responsible for the distribution of the questionnaires to non-PASMEP schools.

Instruments

Questionnaires were developed to determine teachers' perceived needs in relation to teaching mathematics. Each of the three groups answered a different set of open-ended questions which contained at most four items.

In the teachers' questionnaire (Appendix G), the aim of the first question was to get information on the changes these teachers would like to make in their teaching of mathematics. The next question was about their willingness to participate and their reasons for participating in professional development programs. The last question was to specify the teaching strategies in which they felt they needed more assistance.

In the PASMEP teachers' questionnaire (Appendix H), the first question sought perceptions about the need for mathematics teachers to enhance their professional growth. The next question was on professional development activities which occurred in their respective schools, and their views on the results in terms of changes made by participating teachers. The last two questions pertained to their involvement in professional development activities including action research.

The department heads' questionnaire (Appendix I) consisted of three questions which aimed at gathering information about the professional development activities which occurred in their respective schools and their visions for their departments.

Procedure

UPISMED provided a list of schools with PASMEP teachers. Thirty eight schools were identified throughout the Philippines. All schools had one PASMEP teacher, except for two of them which had two. The total number of PASMEP teachers for this study was 40. A letter was addressed to the principal of each school (Appendix J). Attached to the letter were three sets of questionnaires, the permit from the DECS to conduct research (Appendix K) and a letter to the PASMEP teacher (Appendix L). The PASMEP teachers were requested to administer the questionnaires to their respective department heads and one teacher from every year level of their school. To have a more general view of the professional development needs, these PASMEP teachers were also requested to administer the questionnaires to four teachers from a nearby school, preferably, one teacher per year level.

Data analysis

Twenty out of the 38 schools returned the questionnaires. The researcher was made aware during fieldwork that there may have been some communication problems for the distribution of the questionnaires to the relevant people within each school. For example, one PASMEP teacher did not receive the questionnaires and was hesitant to ask the principal about it for personal reasons.

The analysis of these data started before the professional development program. It was necessary to analyze the answers to the questions on teachers' needs at this stage, to assist in the planning meetings scheduled for the professional development program. The final processing of these questionnaires was done together with the data from the professional development program.

The researcher analyzed the answers to each of the questions in four ways. The first was according to the type of school (i.e., whether it had a PASMEP teacher or not). The second was according to the teacher's position. The third was according to the year level the teacher was teaching. This category identified the mathematics content they were teaching. The last was according to the number of years of teaching experience.

It was assumed by the researcher that the above mentioned categories were relevant to the analysis of the results of the study because:

- PASMEP teachers were required to conduct inservice training within their regions, thus probably influencing other teachers;
- the position of the teacher may have been related to how she or he perceived teachers' needs;
- the year level of mathematics taught may have had an effect on the teachers' perceptions due to the differences in mathematics content and the different professional development completed by each of them; and
- the number of years of teaching experience may have had an effect on the way the teachers perceived needs, as more experienced teachers may have had difficulties with change, for example, the use of new technology.

These categories were considered when organizing the data using the NUD•IST (Non-numerical Unstructured Data by supporting process of Indexing, Searching and Theorizing) computer software (Qualitative Solutions Research, 1994). The analysis of data was done in four stages. First, responses of participants to the questionnaires were converted into "text only" files and introduced into NUD•IST. Second, decisions were made on the different major categories which were based on the research questions. Third, an index system was created. Responses of participants on the questionnaires were stored in appropriate nodes forming an index "tree" in which a portion is shown in Figure 1.

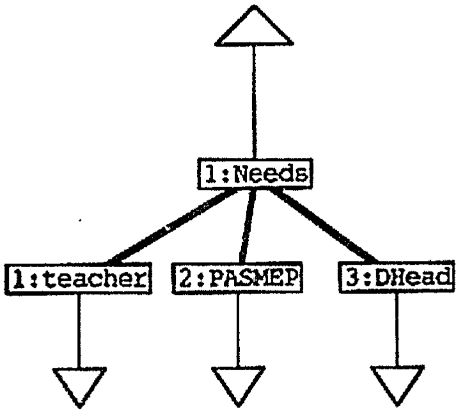


Figure 1: Portion of the index tree.

Last, the data in each node of the tree was explored to provide answers to the research questions relating to needs of teachers. With NUD•IST, it was easy to retrieve text of documents or build new nodes for the analysis of the data. This ease of node building and retrieval operations offered by NUD•IST facilitated the linking of ideas and subsequent construction of conclusions about the data.

Results and discussions

This section contains the results and discussions about the first research question which was on the professional development needs of a sample of secondary mathematics teachers in the Philippines. For the purpose of presentation, the discussion on the teachers' needs will be done in three parts. The first part will be on the teachers' needs as perceived by themselves. The second part will be the teachers' needs as perceived by the PASMEP teachers. And finally, the teachers' needs as perceived by the department heads.

Teachers' needs as perceived by themselves

The discussion on the needs of the teachers as perceived by themselves is based on three questions that were given to them.

In discussing the results it should be noted that:

- about half of the teachers held the position of Teacher 1;
- there were many (36%) who were teaching combined classes of more than one year level of mathematics; and
- a majority of the teachers had teaching experience of five years or less. (This would perhaps explain why many of them were Teacher 1.)

Results of the teachers' answers to each of the three questions are discussed in this section.

Question 1.

Is there anything you would like to change in the way you teach mathematics? If yes, what would this be?

This question aimed to gather information on how many of the 114 teachers would like to make changes in their teaching of mathematics and what these changes would be.

The majority of the teachers indicated that they would like to make changes in their teaching of mathematics. Eighty five teachers out of 114 (i.e., 74%) answered "yes" then gave a list of changes that they would like to make. Some teachers gave more than one suggestion on the areas where they would like to make changes, thus, the total number of changes suggested is greater than 85, as shown in Table 4. Twenty five of them (i.e., 22%) answered "no" or "none" and 4 (i.e., 4%) did not give an answer at all.

Table 4: List of changes that these teachers would like to make

		Areas Where Changes Are Needed							
		Teaching Strategies	Educa-tional System	Tech-nology	Motivation	Visual Aids	Others	No Ans-wer	No/ None
	Total	41	15	13	8	8	7	4	25
School	P	21	8	11	6	6	4	2	14
	NP	20	7	2	2	2	3	2	11
Position	T1	25	4	7	7	5	3	0	11
	T2	3	3	1	0	0	1	1	3
	T3	4	0	1	0	0	1	1	3
	MT	1	1	1	1	1	0	0	5
	NS	8	6	3	0	2	2	2	3
	NA	0	1	0	0	0	0	0	0
Year Level	Y1	7	3	2	2	0	1	0	3
	Y2	4	3	1	1	0	1	2	6
	Y3	7	3	4	0	2	0	0	4
	Y4	3	2	2	4	2	2	0	2
	Co	20	4	3	1	4	3	2	9
	NA	0	0	1	0	0	0	0	1
Teaching Experience (Years)	+0	16	4	2	6	4	2	0	7
	+5	15	1	3	0	2	3	3	4
	+10	5	2	6	2	1	1	0	2
	+15	0	3	0	0	1	0	0	3
	+20	5	4	1	0	0	1	0	5
	+25	0	0	1	0	0	0	0	2
	+30	0	0	0	0	0	0	0	1
	NA	0	0	0	0	0	0	1	1

It appeared from Table 4 that the most frequently mentioned changes were as follows: teaching strategies, educational system, technology use, motivational strategies and use of visual aids. Although, it can be argued that most of these areas for changes would fall under teaching strategies (for example, the use of visual aids would fall under practical work as a teaching strategy), the researcher categorized them separately so as to identify more specifically the teachers' perceived professional development needs. Below is a more detailed discussion of the results for each suggested area of need.

Teaching strategies

The data showed that most teachers believed that they needed to learn strategies in teaching mathematics, other than the use of chalk and board. Their reasons for wanting to make changes in their teaching strategies were varied. Many believed that these strategies would increase the level of mastery learning of their students; help students to absorb the lessons easier; enhance students' enjoyment in the learning of mathematics; increase retention; and better assist them in managing the time allotted for mathematics lessons. They were aware that their usual methods were not sufficient to maximize students' learning. Some commented as follows:

> Not totally change, but something that would vary from blackboard and chalk method. (P, T1, Y3, +0)

This teacher would like to use other strategies that would supplement the use of blackboard and chalk. Another teacher wanted to change from teacher-dominated to student-centered teaching.

> I would like to change the "telling method" in my teaching. I want a method whereby, by just guiding the students, they will learn to discover the mathematical ideas by themselves. I do believe that it is better retained in their minds since it is understood. (P, T1, Y3, +5)

There were teachers who supported this direction using other strategies.

> Yes, I would like to minimize my time allotment for discussion of the lesson. If possible I would like it to be discovery approach on the part of the students but the problem is I found it difficult to direct the students to what I want to come out in the generalizations which resulted from the course of discovering. (P, T1, Co, +5)

It is apparent that this teacher encountered some difficulties in the course of making changes to her teaching.

From the data shown in Table 4, it was apparent that regardless of positions occupied, the year level of mathematics they were teaching, the school where these teachers came from and their teaching experiences, most teachers said they would like to make changes to their teaching approach. In the study of Begg (1994) on the needs of secondary mathematics teachers in New Zealand, it also appeared that many teachers (34 out of 46 that were interviewed) indicated that teaching methods was one of their primary concerns.

Educational system

There were a number of teachers who answered the question by indicating the need for changes in the educational system such as time allotment, class size and curriculum. One teacher commented:

> Yes, I'd like to suggest the topics in Math 1 text be lessened so that there will be mastery. As I see it, we really want to give a little of everything for each area of Math but I believe it does not work. (NP, NS, Co, +15)

This teacher appeared to have a perception that there were many topics in first year mathematics to be covered. She believed that this affected the students' mastery of the topics.

From Table 4, it was apparent that no pattern was observed between the different categories of teachers who commented on changing the system.

Technology use

The desire of some teachers to use technology in the teaching of mathematics was noticeable.

> Since we are already in computer age, maybe math would be interesting to students if sometimes lessons are learned through video tapes and computers. (P, T1, Co, +10)

> The use of overhead projector in the classroom instead of the prepared worksheet on the Teacher Resource Material, using manila paper or writing it on the blackboard. (P, T1, Y4, +5)

They perceived that educational technology, like the computer and the overhead projector, could be used as an alternative to the usual resources they were using in teaching mathematics.

Based on data about the use of technology, 11 out of 13 teachers were from a school with a PASMEP teacher. Eight out of these 13 teachers explicitly mentioned their desire to use computers in the teaching of mathematics. This may indicate the influence that the PASMEP teachers are having with teachers' views about technology.

Motivational strategies

The enhancement of teaching skills was mentioned by some teachers, in particular, how to motivate students to participate actively in the learning of mathematics. Half of these teachers were teaching Mathematics 4. One teacher expressed her belief on this topic.

> I believe I need to improve the art of questioning and also motivation skills so that the students will not find mathematics boring. (P, T1, Y4, +10)

It appeared that even teachers handlirg the senior students saw the need to improve their motivational strategies.

Use of visual aids

Another need seen by many was the use of activities, concrete materials or other teaching devices. One teacher had this view:

> Yes. I would like to use more teaching devices in aid of my lessons. I would also like to adopt new strategies so, I can increase the level of mastery learning with my students. (P, T1, Co, +5)

This teacher had the perception that new strategies would facilitate students' learning of mathematics. One teacher also mentioned that she had been using teaching devices in order to vary the use of manila paper.

> Yes, I would like to minimize the use of manila paper as an instructional material in teaching. If possible, I'd like to use other or variety of instructional aids in teaching. (P, T1, Y3, +5)

It is clear that manila paper has been widely used, and the use of other instructional materials was sought by teachers.

There was no apparent pattern across groups in relation to the perceived needs of visual aids. It was clear that the majority of the teachers who responded "yes" on this first question, would like to make changes in their teaching of secondary mathematics with regard to their teaching strategies.

Of those teachers who answered "no" or "none" to this first question, nine related their reasons to either the mathematics curriculum or the class size. Below are two teachers' comments:

> In my own way of teaching there is no need of changing. What I have observed are the students lack the knowledge of the fundamentals of mathematics maybe due to the SEDP book which are integrated. (NP, NS, Y3, +30)

This teacher seemed to attribute difficulties to the background knowledge of the students and the curriculum, rather than reflecting on her own teaching practices. Another teacher had this comment:

> None. Suggestions: a. The class should not be thickly populated. If possible there are 40 to 45 students in a class so that the teacher can identify the weaknesses of the students in the subject and can vary teaching strategies. b. Make mathematics a one hour period daily so that all students can be called to participate in classroom discussion and participation. (NP, T1, Y2, +0)

This comment seemed to imply that this teacher would like to vary his or her teaching strategies but felt that the class size should be reduced first.

The teachers who answered that they would not like to make changes in their teaching, supported their arguments with the view that implementing the new curriculum and managing large class size seemed to be problems which they would want to address first, rather than changing their teaching practices. Ulep (1993) had previously noted this problem of space, and questioned the effectiveness of learning in such large classes.

The type of school, level of mathematics being taught, position, and the number of years of teaching experience for these teachers who gave negative answers were also considered. Data shown in the last two categories indicated interesting pattern. When the 25 teachers who answered "No" were considered, it was found that 11 (or 44%) of them belonged to a position higher than Teacher 1, and 12 (or 48 %) had teaching experiences of more than 15 years (see Table 4). It appeared that many of those with a higher position and with a longer teaching experience did not see a need for change in the teaching of mathematics.

On the whole, answers to Question 1 indicated that teachers perceived a need to make changes. The main theme for change concerned teaching strategies. This need was common to teachers regardless of the type of school, position, year level of mathematics they were teaching and the number of years of teaching experience. There was also concern expressed about the use of educational technology and changes related to the school system. Although there were quite a number of them (25 out of 114 teachers) who answered "no", it seemed that they were willing to accept changes. However, the changes that they would make to their own teaching would follow changes relating to the school system, for example, class size.

Question 2.

Would you be willing to participate in a professional development program? If yes, explain your reasons for participating in such a program?

This question was given to teachers to find out their willingness to participate in a professional development program and their purpose for participating in such program.

For this question, most teachers responded that they were willing to participate in a professional development program. Only seven answered "no." Table 5 shows the distribution of the answers.

Table 5: Distribution of answers based on the teachers' willingness to participate in a professional development program

Categories	Classification	Willingness to participate	
		Yes	No
	(Total)	107	7
School	P	64	3
	NP	43	4
Teacher's Position	T1	56	0
	T2	12	0
	T3	9	0
	MT	6	4
	NS	24	3
Year Level	Y1	17	1
	Y2	15	2
	Y3	20	1
	Y4	11	1
	Co	40	2
	No	2	0
Teaching Experience (Years)	+0	37	1
	+5	27	0
	+10	17	1
	+15	6	2
	+20	13	2
	+25	3	0
	+30	0	1
	No	4	0

Those who were willing to take part in professional development programs said that the main reason for participating was for professional growth. For them, their participation would mean learning new teaching strategies and mathematics content. Some of their responses were:

> Yes, to increase my knowledge in mathematics so I would be able to teach and use it confidently both with students and teachers. (P, T3, Y2, +5)

This teacher perceived that participating in professional development program would enhance her confidence in teaching as well as the sharing of ideas with colleagues. While this teacher was focusing on acquiring knowledge pertaining to mathematics content, another teacher was more concerned with teaching strategies.

> Yes. As a mathematics teacher in my school, I'm handling first to fourth year math and the only method I know is the chalk and board. (NP, T1, Co, +0)

Professional knowledge was part of the concern of this teacher.

> I would like to participate in a professional development program, not only for professional growth that invariably heighten my sense of security and self esteem, but also to familiarize myself with the progress in educational thought and research and to be more knowledgeable of the current trends and issues in education.
> (P, T2, Co, +10)

It is apparent from these answers that aside from learning mathematics content and teaching strategies, some teachers would also see benefits to their confidence and self esteem as a result of participating in such a program.

Other than the teacher who alluded to a sense of security, no other one of the teachers explicitly mentioned promotion to a higher position as a reason for participating. This is quite surprising because from the researcher's involvement in teacher training, many teache-- would ask for certificates of participation. In the Philippine educational system, certificates of participation would mean earning points which could be used for promotion purposes.

Of the seven teachers who answered "no" to the above question, it was found that six of them also answered negatively to the first question. They all had teaching experience of more than 10 years . The teacher who answered "yes" to the first question and "no" on the second question had less than 5 years of teaching experience. Only one gave an explanation to her negative answer. She said there was no need because she was to retire (in about two months after filling out the questionnaire).

Based on the teachers' answers, it was evident that the majority of them were willing to participate in professional development programs. When considering this view in relation to the categories, it emerged that 4 out of 10 Master Teachers did not see a need for a participation. Most of the teachers believed that participation in a professional development program would benefit them in terms of professional growth as well as their students and co-teachers—for whatever they learned could be shared.

Question 3.

There are other ways of teaching mathematics instead of using, say blackboard and chalk. What other strategies would you like to incorporate in your teaching and you want to be more skilled of?

Data generated here showed that teachers would like to use specific strategies in their teaching of mathematics. There were also answers to this question which were not that specific. For example, some teachers responded with, "any strategy", or "all possible strategies". These items were classified under the category of "others". Specific teaching strategies that were mentioned are shown in Table 6.

Table 6: The different strategies that these teachers would like to make in the teaching of mathematics

		Strategies									
		Tech nology	Group Work	Inves tiga tions	Prac tical Work	Games	Visual Aids	Problem Solving	Others	No Answer	No Change
	To tal	40	22	18	16	16	12	10	11	4	2
School	P	27	16	14	9	9	8	8	2	1	0
	NP	13	6	4	7	7	4	2	9	3	2
Posi-tion	T1	19	13	11	9	8	6	5	4	2	1
	T2	9	1	1	2	2	1	1	0	0	0
	T3	2	2	1	1	1	2	1	2	0	0
	MT	2	4	3	0	1	0	2	1	0	0
	NS	8	2	2	4	4	3	1	4	2	1
Year	Y1	5	3	3	3	1	3	1	4	0	0
	Y2	5	5	2	2	2	1	1	0	4	0
	Y3	7	4	3	4	2	1	4	2	0	1
	Y4	6	3	1	0	2	1	2	0	0	1
	Co	17	7	9	7	8	5	2	5	0	0
Expe rience	+0	16	4	5	6	7	3	3	3	0	1
	+5	5	9	6	7	5	5	2	3	1	0
	+10	9	4	3	1	1	0	3	0	1	0
	+15	2	1	2	0	0	0	1	3	1	0
	+20	6	4	2	1	1	2	0	2	0	1
	+25	1	0	0	0	1	1	1	0	0	0
	+30	0	0	0	1	0	1	0	0	0	0
	NA	1	0	0	0	1	0	0	0	2	0

In Table 6, it appeared that many teachers were interested in the use of technology in teaching mathematics. For most of these teachers, this means that they would like to use computers, overhead projectors, video, calculators and the like. Twenty eight of these teachers mentioned explicitly the use of computers. Below is one teacher's response:

> The innovative approach of teaching mathematics by means of electronic devices like calculators, overhead projectors and slide projectors, television and most modern, through computers, is one effective way of developing mathematics consciousness among students. Along this aspect, likewise, I want to gain more skills in using such devices to cope with the trends and innovations. (P, T2, Co, +20)

Another strategy which was often mentioned was the use of group work. One teacher believed that using this strategy would improve the participation of students especially those who are shy.

> Group activity can be incorporated in our teaching because there are students who are ashamed to do classroom activities but can work better in a group. (NP, T1, Y2, +0)

Another teacher hinted that she would like to have the skills in conducting group work that would help her involve everyone in an efficient use of time.

> Other strategies that I would like to incorporate in my teaching of mathematics and which I would like to be more skilled at are group work and problem solving. In group work, where each member will participate actively and less time to consume. (P, NS, Y3, +10)

The use of mathematical investigations or discovery method was another strategy that was mentioned especially, from teachers coming from a school with a PASMEP teacher (14 out of 18).

> I learned the different strategies from the SEDP training. Since then I've been using these strategies such as discussion, exposition, practical work, practice and consolidation, problem solving and mathematical investigation. I need more skills on mathematical investigation. (P, MT, Y1, +15)

This teacher appeared to have learned the different teaching strategies from the training program and had since been using them. However, she felt she needed to have more skills in the use of mathematical investigation.

Practical work was also mentioned by some teachers. Some suggestions were specific like the use of paper folding and outdoor mathematics. However, one teacher seemed to foresee constraints with this approach in her teaching.

> Practical work. But teachers [need to] be provided with enough teaching aids and how to use them.(P, T1, Y2, +5)

This teacher would like to use practical work as a teaching strategy, however, she was aware that this required access to necessary materials and skills.

Many teachers also mentioned the use of games as another strategy that they would like to consider. Their answers seemed to imply that this strategy should be used with the main purpose being to learn mathematics.

> Playing games—not as motivation but within the content. (P, T2, Y3, +10)

> I would like to incorporate games which are helpful to the students' retention of the lesson. (NP, NS, Co, +0)

It is clear that these teachers would like to be more knowledgeable about the use of games that would facilitate students' learning of mathematics.

As shown in Table 6 , there are ten teachers who would like to use or be skilled in the use of problem solving as a teaching strategy. Data showed that most of these teachers (8 out of 10) come from a school with a PASMEP teacher. Those who expanded on their answers gave comments such as:

> Problem solving where majority of the students will think, analyze and solve the given problem. (P, NS, Y3, +10)

> Problem solving and mathematical investigations suited to slow learners. (P, T1, Y4, +10)

Here, these teachers seemed to perceive the importance of problem solving in mathematics particularly in developing higher order thinking skills such as analysis.

There were also teachers who considered using visual aids in teaching, provided they have access and the knowledge to use them. These teachers seemed to support the statement regarding the provision of materials for visual aids, made by those who would like to use group work and practical work. However, in the use of visual aids, it was not clearly identified by the teachers whether they were for teacher demonstration purposes or for students to manipulate.

Of the 110 teachers who answered question 3, only two responded "no". Both have over 20 years of teaching experience and come from a school with no PASMEP teacher. One said that she preferred the traditional way of teaching mathematics, while the other one believed that she had already been applying different strategies which suited the needs of her students. This seemed to indicate that teachers with longer teaching experience appeared to be content with the strategies they were using. Moreover, they may not be aware of other strategies of teaching as there was no PASMEP teacher in their school which could have influenced their use of different strategies.

Considering all the answers to Question 3, teachers had enumerated a number of strategies that they would like to use in their teaching of mathematics. At the top of the list was the use of technology, particularly computers. This could be related to the country's target of becoming a newly industrialized country (NIC) by the year 2000 (Malacañang, 1997b).

The development of higher-order thinking skills and increasing students' involvement in learning was also one of the teachers' main concerns as many of them mentioned incorporating mathematical investigations and cooperative learning into their teaching.

It was surprising that in Question 1, there were 25 teachers who did not see a need for change in the teaching. Yet, in this third question, nearly all wanted to incorporate some new strategies. It could be that that they did not see change as necessary, but if the opportunity of professional development arose, they would like to be involved.

In summary, almost all of these teachers were willing to participate in a professional development program for their professional growth. These teachers perceived their needs to be mainly in the area of teaching strategies as alternatives to the usual chalk and board method. They indicated strategies that would favor the use of computers and would encourage active participation of students. Considering the different categories of teachers. it was only on the type of school that an interesting observation emerged. Data showed that teachers coming from a school with a PASMEP teacher were able to specifically identify the teaching strategies that they needed. This group of teachers also specifically mentioned the use of group work, investigations and problem solving.

Teachers' needs as perceived by the PASMEP teachers

The needs of the teachers based on the perceptions of PASMEP teachers were also considered. The involvement of PASMEP teachers in professional development activities was also gathered.

There were 18 PASMEP teachers who participated in this part of the study and answered four questions. The results of each question are discussed below.

Question 1.

What professional development do you think is necessary to enhance the teachers' professional growth?

It was expected that this question would give information on the teachers' needs and approaches for professional development as perceived by the PASMEP teachers.

Almost all of them (16 out of 18) agreed that seminars, workshops or any inservice training would help in the enhancement of teachers' professional growth. Some gave suggestions such as these:

Inservice training that would update the teachers in the effective strategies/techniques in the teaching of mathematics. (Bambi)

The latest trends in teaching Math (if there are any) and computer aided instruction in Math. (Celia)

I think it is really necessary for retraining of old teachers as well as new teachers both in content and strategies. But before we do this, principals should be aware of what is going on in the implementation of the curriculum. (Anna)

The PASMEP teachers perceived a need to update secondary mathematics teachers on 'what to teach' (i.e., the content) and 'how to teach' (i.e., the teaching strategy) which could be in the form of seminars, workshops or any inservice training. Perhaps, they felt this way because of the new curriculum in which new topics were included in some year levels and ways of teaching the new curriculum had been suggested (Pascua, 1993).

Six of the PASMEP teachers mentioned teachers pursuing postgraduate studies or attending short term courses (preferably on scholarship grants).

Provide more short term courses for free or scholarships not only in the Philippines but also outside the Philippines. (Heidi)

Heidi perceived that short term courses could help in the professional development of teachers. She also said that professional readings be provided at least quarterly based on the subject they were teaching. This suggestion was also mentioned by another teacher:

An update of the latest innovations or information regarding Math Education through seminar-workshop, professional magazines and other form of math education training. (Liza)

The availability of professional magazines was thought to be helpful in updating teachers' pedagogical knowledge.

Responses to this question indicated that most PASMEP teachers merely listed the various types of professional development programs, without much elaboration, and with inservice training topping the list.

Question 2.

What forms of professional development for mathematics teachers have occurred in your school? How have the teachers changed as a result of this professional development?

Answers to this question would hopefully identify the professional development activities that had been used in the schools where the participants taught and indicate the effects of these activities on teachers.

Except for one of the schools, data showed that professional development programs have occurred in schools with PASMEP teachers. These teachers either conducted seminars, workshops or inservice courses. Other professional development programs were also mentioned. These programs included peer tutoring or study group sessions, demonstration teaching, and attending postgraduate studies and conferences.

Regarding the results of the professional development programs that these PASMEP teachers conducted, most of them gave positive comments. Some of their answers were about teachers teaching better, improving their confidence, and students developing positive attitudes towards mathematics. Below are some of the responses.

> Workshops on teachers strategies had been conducted. After the workshops, teachers found out that the different strategies applied in the classroom, students develop the love for mathematics. (Bambi)

It appears that teachers used different strategies learned in the workshops and found them effective in changing students' attitudes towards the mathematics.

> Since there are two Math teachers in the school peer teaching usually occurs, where they consult each other on some problems and they share resources. As a result, the teachers now use varied teaching strategies and gained confidence in using these. (Aldo)

In Aldo's school, the interaction was limited to two teachers. This approach to professional development appeared to work for them considering the limitation of having two teachers.

There were two out of eighteen teachers who said that little change had occurred. However, they did not elaborate on this. Another said that she had no idea about change since there was no follow up made by her group. The one who answered "none", observed the lack of support from the administrators on whom she depended.

> We need the support of the superintendent, supervisor and principal to allow us to conduct training, seminars, etc. (Anna)

Based on answers to this second question, professional development programs were conducted in schools with PASMEP teachers. Most of the PASMEP teachers said to have observed positive results.

Question 3.

What professional development activities were you involved in since you returned to the Philippines? Please elaborate on its success/failure, objectives and so on.

This question sought to specify the involvement of these PASMEP teachers in professional development activities since their return to the Philippines.

Data showed that they were involved in different professional development activities such as conducting inservice training, workshops or seminars; attending postgraduate courses, conferences and conventions; giving lectures, acting as judges in contests; and initiating school activities such as demonstration teaching and Mathematics Trails. For the inservice training, all of them answered that they were involved in it either on the regional, division or school level. This was apart from the large-scale training of teachers in their respective regions, which was part of their responsibility as trainers, and the curriculum writing workshops in which only two of the respondents were not involved.

With regards to the success or failure of the professional development activities that these PASMEP teachers had conducted, 12 out of 18 responded.

Ten of the teachers said that the results of the activities were successful. Some of the responses were these:

> The lecture-demonstration on geoboard was well responded and appreciated by all participants. (Wendy)

Wendy appeared to assess the demonstration lesson on the use of practical work in teaching as successful and used the participants' reactions as indicators. Aldo had similar responses from participants.

> After each training, the participants are usually satisfied and asked for more similar training especially after a one day seminar. They are also so interested about the TRM's (Teachers Resource Materials, the two volumes of lesson plans), some borrow my copy and have them xeroxed (photocopied) using their own money. With the positive responses, I can say that the training/seminars I was involved in was successful. (Aldo)

The responses of teachers were also the basis of Aldo's evaluation of the success of the program. For Tina, the evaluation was more problematic.

> I conducted a Division Seminar in Math for several times—on the strategies, content, lesson planning and the use of TRM but I have no way of finding [out] whether they are a success or a failure because I am not in a position to monitor the teachers in the division. I'm not sure if the Division Supervisor makes a follow up since she herself showed up once only in the seminar. (Tina)

It is clear that Tina had conducted professional development programs in different areas. However, she felt that any success of the program could only be seen in terms of teacher practices.

Based on their responses, it was apparent that these teachers have been involved in several professional development activities since their return from overseas teacher training. Most of them appeared satisfied with the results of the professional development activities that they had conducted. However, it is clear that their view of success was based on participants' attitudes in the workshops and not on data indicating participants' application of ideas in their own classrooms.

Question 4.

Have you been involved in action research project? Please give details.

This question was directed to find out if these PASMEP teachers had been involved in action research projects and if so, the type of issues they had worked on.

Nine out of the 18 PASMEP teachers claimed to have been involved in action research. Of the nine, three of them explicitly mentioned involving other teachers in their school. One of them had this reply:

> Yes-school level. The project was geared towards the improvement of the performance level of the students in math. Remedial and enrichment lessons were conducted on separate schedule and in all year levels by very much willing mathematics teachers. The project started last year and it's still ongoing. (Marie)

This project appeared to focus on improving students' performance following remedial or enrichment lessons, perhaps depending on the students' abilities.

There were three teachers who worked on individual action research projects. One teacher who focused on cooperative learning had this response:

Yes. I conducted a research project entitled "The Effect of Cooperative Learning to IV-II students, SY '94-'95". The achievement of IV-II students were compared to other sections where cooperative learning was not applied. There was a tremendous difference between the IV-II students' attitude towards mathematics to those who were not exposed to group work. (Heidi)

Heidi's project also focused on improving students' abilities, in particular, their attitudes.

Most of the projects that were mentioned were focused on changes to students' performance or attitude, except for one which appeared to look at teachers' needs.

Yes, "Training Assessment Needs for Teachers". The questionnaire was given to mathematics heads and teachers, and then after processing the answer, we will be able to determine their assessment needs. At present, the group is planning for an appropriate training for these heads and teachers as based on their needs. (Sarah)

Sarah could mean here that they were at the initial stage of their action research program where they were identifying a plan. However, in general, it appears that most of the projects mentioned did not fit the definition of action research used in this thesis.

Of those who answered "no" to the fourth question, Celia and Bambi hinted their interest in action research.

No, but I'd like to try one. (Celia)

No. How I wish I could have been involved in such kind of research, but my hectic schedule would not permit me. Aside from my being full time classroom teacher, a section adviser and a lecturer in Computer Literacy, I also have the Math Laboratory to attend to. I was designated as Head of the Math Department last January 1995. (Bambi)

Bambi's elaboration appeared to explain why they were not involved in action research, even though they would like to be.

In summary, the views of PASMEP teachers were sought with regards to the needs of mathematics teachers and their perceptions on the results of professional development activities and action research in which they were involved. It appeared that the PASMEP teachers perceived that mathematics teachers would still need to be involved in professional development activities, particularly, inservice workshops or seminars to learn more about what to teach, say in a particular year level and how it could be taught. Most of them found these trainings to have positive results on teachers' teaching practices and attitudes and so they considered these as successful. Not a lot of discussion was made with regards to the use of action research. However, the responses to this question indicated a wide interpretation of the term *action research.*

Teachers' needs as perceived by the department heads

Three questions were given to mathematics department heads to find out the professional development activities that have occurred in their departments, the changes that have occurred as a result of the teachers' involvement and their visions for change. Sixteen department heads from twelve regions of the country answered these questions. Half of these were also PASMEP teachers. The results are discussed in this section.

Question 1.

What professional development activities have occurred in your department for the last two years?

This question was intended to gather similar information to that of the second question for the PASMEP teachers. That is, to determine and validate findings about the involvement of teachers in professional development activities.

Inservice training such as seminars or workshops on teaching strategies appeared to be the most common professional development activities that have taken place during the last two years. In fact, twelve of the department heads elaborated on this form of professional development activity. Bambi had this response:

> Short workshop every month on some teaching strategies and also on some very important topics in Math as a sort of refresher for Math teachers. (Bambi)

It is clear that teaching strategies and mathematics content are the topics that were of concern to the department heads. The content areas were considered as refresher courses supporting the new curriculum requirement to teach different areas of mathematics. Teachers were now required to teach algebra, geometry and statistics.

Five of the department heads mentioned group study sessions where a teacher would do some reporting or demonstration teaching. This occurred in Celia's department.

Conducted demonstration teachings with emphasis on learning mathematics through activities. Familiarized the teachers with the use of PASMEP materials during study sessions. (Celia)

Celia appeared to be keen about sharing the use of activities in teaching mathematics with her colleagues.

There were also five department heads who mentioned that their teachers had attended either a convention, conference, short term course or a graduate course.

Teachers attended short term courses in mathematics at UPISMED. Some took up graduate studies. Some attended seminars/conventions and shared whatever knowledge gained with fellow mathematics teachers during department meetings. (Wendy)

In Wendy's department, it was expected that teachers who attended professional development programs would share with their peers the knowledge and skills gained in the program.

One of these department heads declared that there was no professional development activities that had occurred in her department and she gave the following explanation.

So far, there's no [professional] development activities yet except the SEDP seminar that was given by the division which some mathematics teachers attended. We're just organizing the department this year. (Cindy)

Being a newly formed department, there was no self-initiated professional development program.

It was also noted in their responses wherein seven out of sixteen responses that teaching strategies was the main topic for professional development activities.

Responses to this first question revealed that a range of professional development activities have occurred in these schools and most of these activities were in the form of seminars or workshops focusing on teaching strategies.

Question 2.

What changes have occurred in your department and what other changes would you like to occur?

The aim of this question was to find out the changes that teachers may have made and the perceived needs of the teachers in the department.

Results showed that the department heads claimed to have observed changes in teachers' teaching practices and attitudes. Change in teaching strategies was mentioned by half of the department heads. Here are some of their responses.

> Most teachers are using other strategies aside from exposition. (Tina)

> The teachers are now up-graded in terms of teaching competencies and teaching strategies which helped them a lot in the teaching-learning process. (Inno)

These department heads were saying that teachers had become more knowledgeable in mathematics and that they tended to teach more effectively and with less difficulty.

Three of these department heads said they noticed changes in the attitudes of teachers. Some of their responses are:

> There is eagerness to know the latest trends in their field of specialization. (Wendy)

> Teachers were motivated to teach mathematics. (Anna)

> Instructional materials were used as often as possible and teachers showed willingness to learn. (Celia)

Eagerness to learn and to try different teaching strategies and the motivation to teach were the attitudes that were highlighted by these department heads.

Two department heads commented on the changes to students' performance rather than on teaching practices. One of them was very specific in relation to change, saying that the "learning output was increased by 5%" while another one said that "there was an increase in the achievement scores of students, and teachers have less difficulty in teaching mathematics".

Despite the changes that these department heads have observed in their teachers, other changes that they would like to occur were mentioned. Of the thirteen who gave answers to this second question, topping the list for needed change was the use of technology such as computers and overhead projectors. Bambi explained:

We look forward into having a Computer Aided Instruction (CAI) in Math to improve our pacing in the teaching of Math. (Bambi)

Next in the list was teachers' knowledge in mathematics and in teaching strategies. Tina found that certain strategies could contribute to the development of cognitive skills:

I wish that all the teachers will adopt the present strategies introduced in Math that would develop thinking skills of the students, [and] that all the teachers would make use of activities in their lessons. (Tina)

There were also two department heads who mentioned class size, time allotment for mathematics, load of teachers and library facilities.

There should be more magazines/periodicals regularly published for our references, so that teachers may also be updated of recent teaching strategies/math concepts. (Celia)

Celia apparently believed that mathematics magazines could help teachers in their professional development.

Based on the department heads' answers to this second question, it can be said that changes are perceived to have occurred in these schools and that the noticeable ones were teaching practices where different strategies were already in use. Seminars or workshops were seen as helpful in bringing about changes to teaching practices. Nevertheless, these department heads would like to see other changes occurring in their respective departments specifically in relation to the use of technology.

Question 3

How would you imagine your mathematics teachers may be teaching a few years from now (say three years from now)?

This question sought department heads' vision for their departments, particularly in relation to how their teachers might teach in the future.

Of the sixteen department heads who answered this question, twelve of them said that teachers would be using technology, half of them specifying the use of computers. They imagined that teaching with the use of technology, could be described as follows:

> If there will be audio-visual aids, there is less teacher talking but rather, more of students' activity. Chalkboard would be replaced with OHP (overhead projector). Installation of a TV set, a computer unit in every math classroom. (Iris)

> I could imagine my mathematics teachers teaching problem solving through the use of computer. (Lyn)

> Teachers teaching through radios and television. *Ambisyosa ha* ! (Ambitious, right!) (Marie)

It was interesting to note that one of the department heads admitted to being quite ambitious in the use of technology in teaching mathematics, for technology such as television was not commonly used in class. There were also responses that were not directly pertaining to teaching such as time allotment for mathematics and setting up a mathematics center.

The responses to this question indicated that department heads imagined their teachers using technology that included computers, televisions and overhead projectors.

Based on the three questions, the views of the department heads appeared to indicate a need for continuous professional development of their mathematics teachers. This professional development should concentrate on enhancement of teaching strategies including the use of technology, such as computers.

Summary

Teachers' professional development needs were sought through questionnaires. The participants were teachers, department heads and PASMEP teachers from almost all regions of the country. Data were analyzed with the use of the NUD•IST software.

Results of the analysis showed that the teachers needs as perceived by themselves were primarily on ways of teaching mathematics other than the chalk and board, and possibly with computers. In this regard, it appeared that they were willing to attend professional development activities because most of them believed that it would help them grow professionally.

It was found that PASMEP teachers' perceptions about teachers needs were in agreement with the perceptions of the teachers themselves. PASMEP teachers said that there was a need for teachers to be involved in professional development activities such as workshops and seminars particularly in relation to teaching strategies. Based on their experiences in conducting such professional development activities, they found these activities to be successful in changing teachers' teaching practices and attitudes.

The views of the department heads were also similar to those of the first two groups. They felt that there is a need for continuous professional development activities in their respective departments that would enhance teaching strategies. They were also concerned about their teachers' future use of technology, such as computers.

It emerged from this study that secondary mathematics teachers' professional development needs were mainly related to teaching strategies. The participants in this study perceived that this need could be assisted through professional development programs such as seminars or workshops.

It was also apparent that the professional development activities that were prevalent were in the form of seminars and workshops. No mention was made about professional development activities in which the teachers were involved in designing their own professional development activities nor about action research as a form of professional development activity. In the next chapter, a discussion on this form of research will be made based on a group of mathematics teachers who were involved in a school-based professional development activity.

CHAPTER 5

The Action Research

Introduction

This chapter will discuss a study in which action research was used as a model for school-based professional development. Specifically, the chapter will focus on the second research question: How effective is action research as a school-based professional development model for a group of secondary mathematics teachers in the Philippines? To answer this primary question, two secondary questions pertaining to the effects of action research on teacher's pedagogical knowledge, and their beliefs and practices were considered. The details of participants, design, instruments, procedure, data analysis and results are included in this chapter.

The participants

The study was carried out at a high school in the Philippines. Description of the participating school such as its location and its organizational structure as well as the professional background of each participant will be discussed in this section.

Description of the participating school

The participating school is in a town about 36 kilometres from Metro Manila, the capital of the Philippines (refer to Appendix A for the map). It is built on a hilly locality which is about five kilometres from the political and economic center of the nearest town and about two kilometers from the main road. Because of its distance from the main road, students usually take two modes of transportation to reach the school: first by a jeepney, then by a tricycle. A jeepney, which services the main road, is a colorful vehicle which has a seating capacity of about 18 passengers. In this vehicle, there are two long benches on opposite sides and this arrangement enables the possibility of conversations amongst the passengers. It is common to hear students sharing stories while on a jeepney. The other vehicle that the students use, the tricycle, transfers them from the main road to the school. This vehicle is a motorbike with a two-seater carrier attached on one side, making this a three-seater vehicle where the third passenger is behind the driver.

The school is the only public secondary school in town and it was established in 1991. When this study was conducted, the school was in its fourth year and it was the first time it had the complete four year levels.

Basically, the school is made of either one-storey or two-storey concrete structures consisting of 28 classrooms. These classrooms are positioned such that they enclose a rectangular-shaped open area. An open corridor separates the open area from the classrooms. At each corner of the corridor there is a large table and some chairs. At the time of the study, construction works were being carried out for a two-level structure. Provisions were made for a school library and a staff room. At the end of the study, most of the construction works appeared to have been completed.

At the highest level of the school's organizational structure were two people: an officer-in-charge and a head of school. Both shared the same managerial responsibilities, although occupying different offices. This arrangement, of having two people in the top level, is not a common organizational structure in secondary schools in the Philippines for usually a school is headed by just one person, a principal. However, it was explained that this arrangement will just be for one year to give support to the head of school who was new then.

Apart from the two persons mentioned above, there were 66 teachers in the school. Depending on their field of specialization, each of them was assigned into one of the eight subject areas. In the school year 1995-1996, each of these subject areas was organized as a department, with the mathematics department consisting of nine teachers.

During this study, it was observed that teachers tended to group themselves according to the year level they were teaching. They would select one corner of the corridor to leave their belongings on the table and this place also served as a meeting place, mainly during the break.

The number of teachers in each year level varied depending on the number of students. For example, the first year level had the most teachers because it had the greatest number of students. There were over one thousand students in each of the first and second year levels, over seven hundred in the third year level and about four hundred in the fourth year level. The distribution of students by year level is shown in Table 7.

Table 7: Distribution of students according to year level

Year Level	Number of students
First year	1222
Second year	1029
Third year	727
Fourth year	401
Total	3379

Note: The figures were obtained from The Mean Profile, Department Head's quarterly report.

Based on the fact that there were 66 teachers, 28 classrooms and 3 379 students, it may appear that there was an average of 120 students per classroom and about 51 students per teacher, assuming that all teachers had the same teaching loads. (A teaching load is the number of group of students, called a 'section', a teacher is assigned to teach). These figures tend to indicate that there is a lack of classrooms and teachers in this school. In reality, teachers taught approximately 50-80 students in a class depending on the year level. Classes were scheduled in two shifts during the week and a teacher would work only one shift. Some groups of students would be in school during Mondays, Wednesdays and Fridays while the rest would be during Tuesdays, Thursdays and Saturdays. This shift system was later changed to classes from Mondays to Fridays, still two groups, one starting at 5:45 a.m., and the other at 12:55 p.m..

Background of the participants

The group undertaking the professional development consisted of five teachers including the department head. Assisting the process were the head of school (who was also the PASMEP teacher) and the researcher. The researcher acted as a participant-researcher with these roles: member of the group in the effort to enhance the teaching of mathematics and as a researcher who documented the experiences of the group. In general, the participating teachers in this study were new in their job and mostly young. What follows is some information on the background of each participant.

Delia, the PASMEP teacher and the head of school, was about a month in the job when this study started. She used to be a department head in mathematics from another school and a regional trainer of teachers handling mathematics in the third and fourth years, both from public and private schools. She attended several inservice training programs such as those conducted at the University of the Philippines and the PASMEP training in Australia.

Cindy, the department head, was a graduate of Bachelor of Science in Mathematics. She began this position as a department head at the same time as the head of school. She also acted as a Girl Scout Coordinator and did some administrative works such as the teachers' payroll, Form 3 reports and quarterly reports. She was one of the pioneers in the school and was in her fourth year of teaching secondary school mathematics. At the time of this study, aside from those jobs mentioned above, she also had four teaching loads in third year mathematics. She had attended a week of SEDP training in mathematics teaching.

Teresa was the teacher assigned in Mathematics 1. She taught eight classes and also acted as chairperson of teachers teaching first year students. This was her second year in the school and her first time teaching mathematics. In the past she had been teaching classes in science and language (Filipino), subjects which were not her major for she finished Bachelor of Science in Education major in mathematics.

Alex taught seven classes in Mathematics 2 and two classes in Technology and Home Economics. This was his third year in the school and he had taught Mathematics 2 in the past. He was also negotiating salaries on behalf of the school employees. He graduated with a degree of Bachelor of Science in Education major in mathematics.

Art, who was a graduate of Bachelor of Science in Accounting, was in his third year in the school. He taught eight classes in Mathematics 3. In the previous years, he taught mostly social studies while mathematics was just a filler to his load. He was also involved in the training of students for athletic competitions.

Bert taught Mathematics 4 and physics and had nine loads. This was his first time teaching the two subjects. The previous year, when he joined the school, he was assigned to teach Mathematics 1. He used to be a primary school teacher in a private school and had attended an SEDP training. He was a graduate of Bachelor of Science in Mathematics and has to do a thesis to complete his master's degree.

Design

To ascertain the effectiveness of a school-based professional development program conducted with the group of five mathematics teachers in the Philippines, an action research method was chosen.

Action research as a method was employed for several reasons. Firstly, it is a method designed to achieve both change and learning from the results of the changes (Kemmis & McTaggart, 1988). The method is appropriate to use when determining changes that could occur in teachers' pedagogical knowledge, practices and beliefs as well as providing understanding about these changes. Secondly, this is a method as Dick (1994) argued, that provides the flexibility and responsiveness that are needed for effective change and at the same time it provides a check on the adequacy of data and conclusion. Thirdly, the method provides a framework for the process of change. As Cohen and Manion (1994) said, action research is a method appropriate for "inservice development of teachers—improving teaching skills, developing new methods of learning, increasing power of analysis, of heightening self-awareness" (p. 194). Lastly, action research can be participative in nature enabling the combination of independent and collaborative work of researcher and teachers. Here, the teachers have the opportunity to learn, in their own way, how to improve their practice and change existing conditions. In addition, this form of research may engage participants in critical inquiry and a questioning of system policies (Zuber-Skerritt, 1993). Furthermore, Uhlman (1994) argued that for real change to occur, there should be participation by the people involved in the situation.

In this study, the action research spiral of Kemmis and McTaggart (1988) was the basis for assessing the progress of the project. A modified version of this action research spiral is shown in Figure 2.

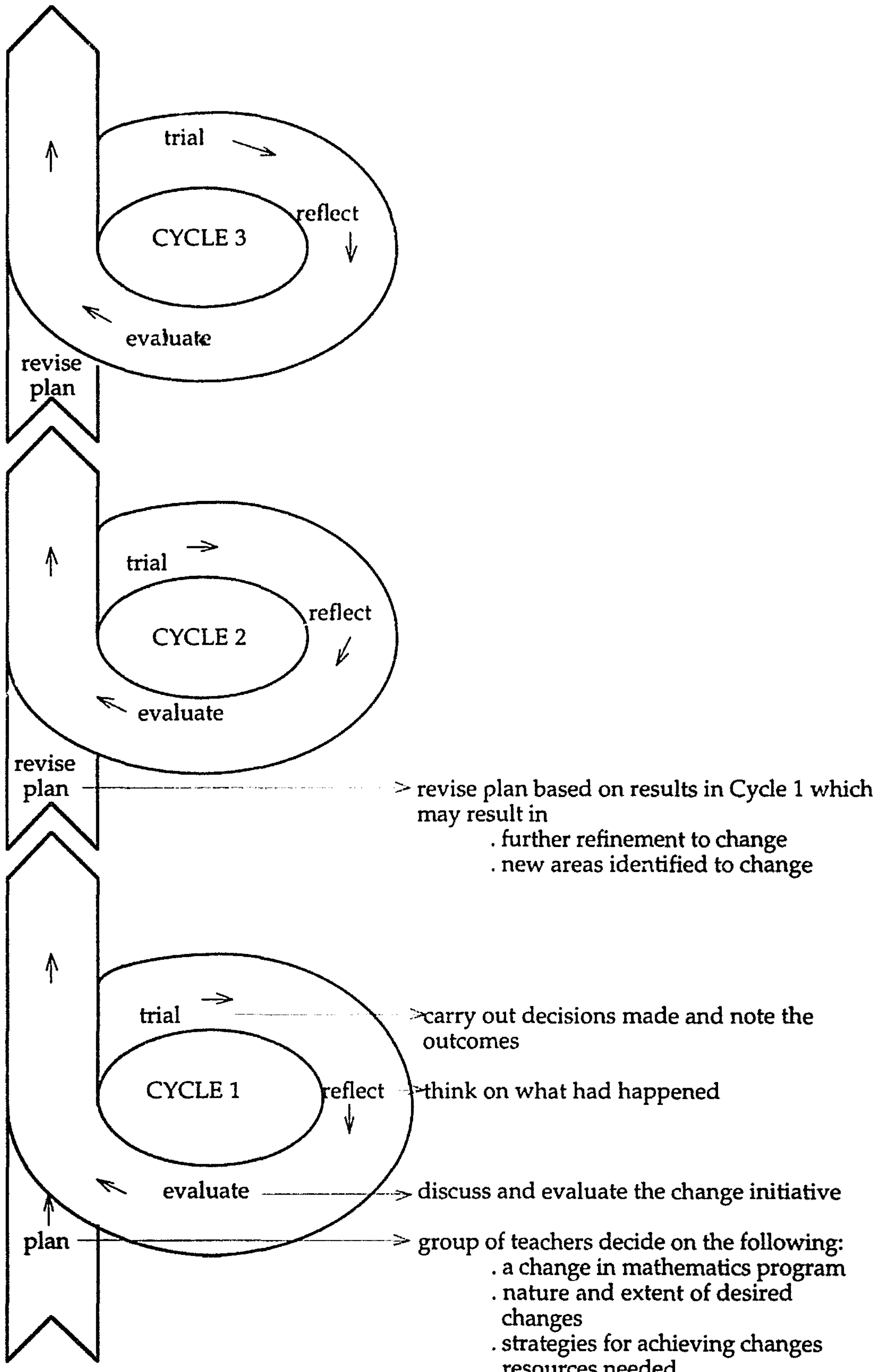


Figure 2: A modified version of an action research spiral

Instruments

In order to obtain rich information on the changes made by the teachers as a result of their involvement in action research, different instruments were used. Elliot (1991) made a list of techniques which can help in gathering evidence during action research. Most of the identified techniques were used in this study. Below are descriptions of each of the instruments used.

Questionnaires

Three sets of questionnaires were used to find out the needs of this group of teachers. These were the questionnaires described in the preceding chapter (also refer to Appendices G, H and I). The researcher administered these questionnaires at the start of the study. The questionnaires gather data on the needs of the teachers and their willingness to participate in a professional development program. These data were used in the planning stage of the action research.

Interviews

Individual and group interviews were conducted by the researcher as one of the instruments to answer the research question on the effects of action research on teacher's professional growth. Some of these are semi-structured, like the initial and final interviews about changes in teaching, beliefs and practice (refer to Appendices C and D), while others are unstructured, especially those during meetings. These unstructured interviews provided the opportunity for the researcher to explore further and to gather information which was not easily obtained in other ways. The interview results were helpful in the planning and reflecting stages of the action research.

Class observations

To supplement the questionnaires and the interviews, class observations were made mostly by the researcher and in some occasions the head of school and some mathematics teachers. Before the action research started, portrayal of the whole session was written after each class observation. The results of these class observations were used during the initial planning for the action research. Then, during the action research, portrayals were written by the researcher focusing on the descriptions, results and suggestions of the activities that were used. In the reflection and in the revision of plans, these observation results were the basis for discussions.

Diaries

Each of the participating teachers kept a diary of the sessions in class whenever practical work was used to keep track of the changes. In addition, all participants in the study kept a diary of meetings recording their reflections, feelings, observations or explanations (refer to Appendices M, N and O for the suggested format). This way of recording data was useful in the reflection and in the revision of plans.

Photographic evidence

To capture the visual aspects of the situation and to provide the basis for discussions during meetings, photographs were taken by the researcher.

These focused on teachers' activities, students' activities, resources used and organization in the classroom. Only teachers were identified in photographs. The photographs showing students were intentionally altered to remove their identity.

Audio or video taping

Audio and video tapes were used in interviewing and in observing some classes. Audio tapings were done by the researcher using microcassette tapes. On the first few days of class observations, video taping was done by the researcher's colleague. These video tapes were viewed by the group to help in the initial planning of the action research. During the action research, at meetings, group interviews and at some lessons, video tapings were done by the researcher. These tapes were efficient in recording class observations and meetings which were useful in the reflection and evaluation of the activities.

Document Analysis

Other than those mentioned above, other documents were gathered such as teachers' lesson plans, copies of activities used, quarterly reports of the department head and the observation reports made by the head of school. These provided information which sometimes were relevant to the problems being explored.

Procedure

Four phases were considered. These were the selection of the school and its participants, the assessment of the existing conditions, the action research and a final evaluation. These were undertaken from July 1995 to February 1996.

Selection of school and participants

The selection of the school was based on two criteria: presence of a PASMEP teacher in the school and its location relative to the researcher's home or office.

The presence of the PASMEP teacher in a school was assumed to be of help to the researcher. Given the wide range of professional development programs in which each of them had participated, their presence would facilitate the changes which teachers may wish to make. Also, the previous experiences of the researcher working with PASMEP teachers during seminars and workshops, could establish harmonious relationships at the outset. Another consideration was the proximity of the school to the researcher's home and office for accessibility.

With the reasons mentioned above, the researcher contacted a school which was walking distance from her home. Unfortunately, it was learned that the PASMEP teacher in that school had moved to another school, but was still the most accessible to the researcher's home or office. Thus, when contacts were made, informal agreements on the conduct of the study were also made. Names of possible participating teachers were mentioned by the head of school and the department head, and these turned out to be the final ones when they were consulted about their willingness to participate.

Formal arrangements for the conduct of the research in the chosen school was made through the proper authorities. Permits were secured from the division superintendent and this was forwarded to the chosen school. The permit specified that no disruption of classes for the conduct of the research was to be made (Appendix P). The officer-in-charge of the school provided the researcher with a permit to undergo the research (Appendix Q). This matter was then referred to the head of school who introduced the researcher to the participants. A brief background of the project was then given. Negotiations of times for interviews and class observations followed. Consent forms (Appendix R) were signed by all participants.

Assessment of the existing situation

To find out the existing situation, particularly in relation to the teaching of mathematics, questionnaires were given and interviews were conducted. Class observations were undertaken for about one and a half months. Below is a detailed discussion on how this assessment was conducted.

Questionnaires

The four teachers, Teresa, Alex, Art and Bert were given a one-page questionnaire requiring some information about themselves and three questions about their professional development needs as specified in Appendix G. The department head, Cindy, did the same but using a different set of questions (refer to Appendix I). Another set of questionnaires was completed by Delia, the PASMEP teacher and the head of the school (refer to Appendix H).

Interviews

An individual interview with each of these four teachers and the department head was conducted by the researcher at the office of the head of school. This interview was semi-structured and for most of the time, the researcher used the Filipino language so as everyone could expressed their ideas comfortably. Group interviews were also done in the same room and in a similar way to the individual interviews in terms of structure and language. The group interview was audio recorded to provide a reliable data for the transcription and analysis.

Class observations

Arrangements for the class observations by the researcher were made with each of the four teachers and the department head. It was agreed that most of the observations would be unannounced, except for a few where the exact day and time would be made known to the teachers. This arrangement was agreed to minimize class disruption and the student' feelings that there was an observer in their class which may cause them to behave differently. It was also agreed that teachers would expect the researcher to enter the classroom very quietly through the back door and with no introduction. For the announced observations, the teachers' preferred time was given to the researcher along with the rest of their class schedules.

In the first two weeks of the scheduled observations, each of the participating teachers was observed in at least three consecutive lessons, one of which was video recorded. The video was taken by an officemate of the researcher. A compact video recorder was used, with no extra lighting. It was thought that the presence of lighting may further distract the students.

A time was set when the video tapes taken during these announced observations were viewed by the group of teachers. This was considered as the class observations made by the group. Critiquing by the group was done after the viewing. The head of school led the discussion by letting the teachers give further explanations as to what they did, why they did it that way and any change that they would like to make if they were to give the same lesson again. After a teacher had finished giving her or his comments, the rest in the group gave comments or suggestions.

The action research

The action research cycles

The group agreed to undertake an action research approach to increase students' participation through practical work in the teaching of mathematics. The action research included three cycles and several stages were considered in each cycle. How the group came up with the focus on the use of practical work and what happened in each of the three cycles are discussed in more detail in this section.

Cycle 1

Cycle 1 covered a period of about two and a half months, from the planning meeting to the first evaluation meeting.

Planning

Planning meetings were conducted in two sessions, 30 to 40 minutes per session and a week apart. The meetings were in two sessions because the participants' schedules were too tight for the group to meet once for a longer period of time. These meetings were held informally at the school head's office.

A brief discussion on the nature of action research was led by the researcher at the start of the planning meetings. A one-page handout of the action research cycle was distributed to each of the teachers. Their reactions were sought and all of them appeared willing to be involved.

During the first planning meeting, the fourth year teacher was not able to attend because there was a change in the schedule of classes for that year level. The head of school was also unable to attend because of another meeting. However, the group decided to go on with the meeting and came up with the following list of topics that they would like to consider for their action research:

- variation of examples given to students during discussions of lessons
- use of visual aids, particularly manipulatives
- how to motivate students in learning mathematics
- other teaching strategies
- activity approach
- group work

- use of games and puzzles

These ideas of topics to consider all came from the teachers. Before the end of the meeting, it was agreed that they would think about which topic they would really like to work on.

In the second planning meeting, the teachers made the decision to work on students' participation. When asked how this would be done, they said they would use activities, particularly manipulatives, in their teaching of mathematics. So, the use of practical work as a teaching strategy was their choice. When this was agreed on, the group tried to determine the possible problems that could occur during the implementation and possible solutions, as shown in Table 8.

Table 8: Anticipated major problems and suggestions

Problems	Suggestions made by the group
Where to find the materials	• use the PASMEP resource materials for the activities • go to the UPISMED library for mathematics magazines, books and to see samples of manipulatives • let students make some of these manipulatives as their projects
Where to save time	• use ready made activities to save preparation time • assign part of it as homework and discussion of results in class • use group work
How to cater to students of mixed abilities	• explain directions first • relate to real life or *sa uso* (in fad)

It was also agreed that at least five activities, about one activity per week, using manipulatives would be trialed for the first action research cycle and that the method of implementation in the classroom would be discussed with the group. A discussion about group work would be led by the department head at the next meeting.

The group agreed that most observations would be done by the researcher and at times by the head of school and the department head. The group also mentioned a need for some inservice workshops. So, it was planned to have one workshop every cycle, the workshop topics were to be decided by the teachers.

Trialing of plans

The teachers trialed the activities in their own classes. These activities were taken from different sources such as books lent by the researcher, the PASMEP resource books or they prepared themselves. Often, they would first ask either their peers, or the head of school or the researcher about some aspects before using the planned activities. Observations were made by the researcher in most of the lessons where the participants used activities. A diary entry was written by the researcher after each observation. A diary of the activity was also kept by the teacher. Lesson plans and activity sheets were also collected.

Only one of the teachers was able to try five activities in class, as agreed. One of them was able to try only two activities as she became sick. For the rest of them, each of them tried four activities. Most of their activities were taken from the PASMEP resource book (a PASMEP resource book contains lesson plans and activities for students' use) or from the books lent to them by the researcher.

Reflection and evaluation

Reflection and evaluation of the class activities based on the teachers' diary entries were undertaken during the end of cycle meetings. The minutes of the meeting were documented by the researcher through note taking and audio tapes.

In the meetings, the following key points were used as a framework for discussion:

- a recall of the action research cycle
- general comments on what happened during the trialing
- reflecting on what have been done or have not been achieved
  - -number of activities that have been tried
  - -compilation of activities used
  - -use of group work in teaching
  - -sharing of activities with peers
  - -gathering of activities from books
  - -assigning projects to students
  - -presenting and discussing the activity to the group before using it in class
  - -completing a diary
- reflecting on success of action research cycle in terms of
  - -students' participation
  - -teacher preparation and professional growth

- what they liked and did not like about their participation in the project
- reactions to the inservice workshop

This framework for discussion enabled each participant to share their experiences with the group and resulted in revisions of plans needed for the next cycle.

Cycle 2

About one and a half months was allotted for cycle 2. In reality, it was about three weeks because of holidays, a sports meet and a typhoon.

Revision of plans

Based on the reflections and evaluations from each participant, changes for the implementation of cycle 2 were agreed on as follows.

The number of activities to be tried in class was left in the discretion of the teachers. This meant that, for example, in one week, three activities could be tried in class, and in another week, none. It was argued that there were topics where many activities could be used to discuss the concepts, and there were topics where suitable activities were difficult to find.

It was agreed that in cycle 2 a record of the activities would be kept for future use. The researcher agreed to record the activities used in cycle 1 which were not taken from the PASMEP resource book.

Students were to be allowed to work in groups during activities, with some changes to the approach used in cycle 1. It was suggested that group size would not be flexible and dependent on the selected types of activities. Each group would not be required to discuss all of the results of the activity in class, but would be asked to confirm, reject or give additional information to what had been reported by one group.

Sharing of activities with colleagues would continue (especially those teachers teaching in the same year level). However, discussion of activities with group ıembers before using them in class appeared difficult to do. The conflict in schedules and the lack of familiarity with mathematics content in other year levels were the main causes of this difficulty. Nevertheless, the discussion of planned activities would continue between the teacher involved and either the head of school or the researcher.

Three of the teachers were able to collect materials from students' projects. They agreed that they would continue with the collection of materials as projects and kept the reusable ones ın a place where other teachers would have access to them.

Finding time to go to the library was a problem in cycle 1. The distance of the school from a library required a lot of time for travel. Furthermore, the library was closed on weekends. Thus, teachers agreed to go to the library during the next cycle on a day when they would be otherwise at a sports meet.

Trialing of plans

The teachers went through similar processes as described in cycle 1, this time agreeing to further revisions.

Reflection and evaluation

The framework for discussion used in cycle 1 was again the basis for reflection and evaluation for this cycle. The results that arose from this stage were the revised plans for the third cycle.

Cycle 3

This cycle lasted for about one and a half months and was to be the last cycle the participants would complete for the study.

Revision of plans

Changes made for this cycle were based on the cycle 2 reflections. Basically, the group agreed to continue what had been done in the previous cycle, with minor revisions as discussed below.

Each one of the teachers would prepare at least two activities to be trialed in class. A video would be taken of one of these activities. It was also agreed that before using the activities, consultations would be made with other group members. If possible, an initial outline on how to use the activities in class would be presented to the group for comments.

The use of mathematical investigations would be tried in class especially with the groups of students belonging to the top sections.

Trialing of plans

Revised plans were trialed in class. Each of the teachers presented a lesson where a video was taken. In this case, the teachers used practical work as a teaching strategy. However, the trialing of mathematical investigations was not done as the teachers were unable to find the time to introduce them.

Reflection and evaluation

As in previous cycles, the discussion of what occurred was based on the same framework. The department head led the discussion by referring to the guide questions in the framework.

The inservice workshops

The topics chosen by the group for inservice workshops in every cycle were perceived by them as ideas that would be helpful in their action research. The topics are shown in Table 9.

Table 9: Topics, facilitators and participants in the workshops

Action Research Cycle Number	Topic	Facilitators	Participants
1	Teaching Strategies Group Work	PASMEP teacher Department head	Mathematics teachers (school level)
2	Use of Visual Aids Calculators Problem solving and investigations	A guest lecturer Researcher Department head and researcher	Mathematics department heads and teachers who had not attended any inservice course (division level)
3	Mathematics as Communication and Reasoning Mathematical Modelling	Department head Researcher	Mathematics teachers (school level)

The cycle 2 workshop was attended by the department heads and mathematics teachers in the division level. This means that the participants came from different schools that comprised the division. In this particular workshop, the assistant superintendent of schools was present at the opening ceremony and the division mathematics supervisor was also present and attended all the sessions.

Final evaluation

At the end of the third cycle, the participants in this study met to reflect on what was done, and its effects or impact of the project on their professional growth. Suggestions that could be helpful in their future teaching were also discussed.

Data analysis

Questionnaires, interviews, class observations, meetings, diaries and other documents were analyzed using the NUD•IST software (Qualitative Solutions Research, 1994). The process used in analyzing data obtained from the above mentioned instruments was similar to the one described in Chapter 4 for analyzing teachers' needs. However, more categories and sub-categories were created to answer the research questions relating to changes in teachers' pedagogical knowledge, teaching practices and beliefs.

To facilitate the encoding and the analysis of data, codes were used. For example, FGI meant *Final Group Interview* and III meant *Initial Individual Interview*. All the codes used are included in Appendix F.

Results and discussion

The results and discussion of the effects of action research on teachers' professional growth will be discussed in two parts: the professional growth of each participating teacher and the general changes that were observed in terms of pedagogical knowledge, teaching practices and beliefs.

Professional growth of the participating teachers

The professional growth of each of the five participating teachers in terms of changes in pedagogical knowledge, teaching practices and beliefs were considered by the researcher, the head of school and by the teachers themselves. In a few cases, comments from their colleagues were also noted. Conclusions about the teachers' professional growth was based on the data obtained from class observations, interviews, diaries and discussions during meetings.

Teresa

Personal view

Teresa's personal view about her personal growth is reflected in her diaries, and in her statements during interviews and meetings. She felt that her involvement with the group enabled her to grow professionally.

When asked to give a short statement on the impact of her involvement in this study, she said:

> Improvement and learning. Learning from what we did. Just like this. What I learned before, I realized, it was not enough. So, with the group, they were able to help me. Honestly, this is my first time to teach math, I don't know some of it, I just learned it. (Cycle 3 meeting)

Being new to the teaching of mathematics, the learning that she was referring to may include both the mathematics content and teaching strategies used. The "learning and improvement" could be the result of her recognition of students' motivation and her willingness to prepare suitable activities.

> Since we used activities, I'm always thinking. I'm always preparing an activity because I observed from my students that they really liked to do an activity. But it couldn't be that everyday there's an activity. So now, as if I'm the one getting assignments from my students. (Cycle 2 meeting)

She seemed to be encouraged by her students to do well in her preparation of lessons. She made a similar statement during the third cycle meeting.

> First, your lesson will be few days from now, but you have to think about it. As if, you really have to prepare for it for your students, not tor yourself. Why I said this? For me, I can do it because I'm always ready, those materials, something like that. I think about it, I do it. Even the students don't have it as long as I have my own. Sometimes I let the students bring it, but you're not sure whether the students will bring it. At least I can do it. So, something like, I won't be embarrassed if they have none when I say that tomorrow we'll do this. When we're there, they have nothing, at least I could still present mine. There would be awareness. (Cycle 3 meeting)

Here, it appeared that she was concerned to carry on with her plans. She planned to use her own materials in case her students did not have the required ones. She also shared with the group about the changes she has noticed in her students.

> Their [students] questions now are different than before. They're really got encouragement from the activity. Really, I noticed that when we started using activities, they like it. (Cycle 2 meeting)

She related her students were encouraged to participate and to ask questions because of the activities. This led her to be sensitive to students' needs.

> I'm becoming sensitive about questions asked by the students. Now the students like to ask questions. Oftentimes I would make it a suspense. Sometimes they're the ones asking me questions. They're now the ones giving us a problem! (FGI-Beliefs and Practices)

This tend to confirm that her students changed their attitudes towards learning mathematics. As a consequence of this change in attitude, she actively looked for ways to change her questioning techniques. In her diary, she had written the following comments about her roles and contributions to the project:

> I act as member as well as a participant. Why? Because I gave some suggestions, shared my ideas, gave comments everytime there was an activity. I participated also in the discussion. I always gave the best that I can do because it helps me a lot not only as an individual but as a mathematics teacher. As part of this project, I can say that I really gave the best that I could do by means of preparing the materials very well.

It is interesting to note that she said she did her best to participate in the activities of the group. She even viewed her participation to be helpful for both her personal as well as her professional growth. Also, through her diary, she shared her feelings about her interactions with the group. She wrote:

> I enjoyed it because I learned with them. I feel proud because I'm with the group. I grow professionally and I learned from the group. I am learning with the group because there are some topics that I can't understand so with this interaction I am improving in my teaching style.

The feeling of enjoyment, the pride derived from being a member of the team and the learning she claimed she was getting, could explain why she participated actively in this project. Another personal view that could be interesting to note was her final assessment of herself. In her last diary entry, she wrote:

> I feel that I'm always ready to face the class because I am also preparing materials for myself. Thank you very much!!! (Classroom diary)

She felt that her involvement in the study enhanced her confidence in teaching mathematics. Her willingness to cooperate in the project was also reflected in this interview response:

> For me, sometimes it is said that you do it that way to show to others or because Ate Flor needs it . Of course for me, I would be fooling myself if I'll do that. It's because you help us on how to teach math. I realized there are other techniques [in teaching] where the students are enjoying. So, that seemed to be a big help for us. So in return, would you think it will still be the same? Because of that, not because I'm involved in the project why I did the activities. Not that, that's how I looked at it. I don't know. (FII-Beliefs and Practices)

Here, she was referring to a willingness to try different teaching strategies that were enjoyed by her students.

Head of school's view

Delia, the head of school had observed Teresa's class on three occasions, twice in class and once on a video recording. She noticed that Teresa was using visual aids in her teaching and she described this in one of her reports.

> The lesson was presented using a circular device which was manipulated by the teacher. Question and answer was used to derive the concept. (Delia, Monthly observation report)

The use of visual aid and the questioning technique of Teresa could have impressed Delia since these were the highlights in her report. However, not many comments were mentioned by the head of school. She said that the lesson presented by Teresa was very similar to her first lesson. For the head of school, Teresa was already doing well. Similarly, in her video recorded lesson, the head of school had this comment: "For Teresa, her first video was already okay".

Researcher's view

Observations made in class and during group discussions revealed that the professional growth of Teresa was mainly to do with teaching strategies.

Before the action research began, it was observed that her usual classroom routine would consist of students answering the assignments. Her lessons would be presented using blackboard and chalk and she would be talking most of the time while the students would be just sitting and seemingly listening. Students were then given practice activities and later some of them were requested to write their answers on the board. Visual aids were used at times. These were mostly made of brown paper, with some notes or exercises written on them. Flashcards for students to practice skills on mathematical operations were also used.

During the initial interviews and discussions, she talked about some issues but would not elaborate. An example of this was when she mentioned students as appearing to be the "receivers" of knowledge.

Researcher:	So if the teacher is the giver of knowledge—is this the case? (A nod from the teachers). What do you think would be the role of the students?
Cindy:	Not all of them are very good, that's our problem
Teresa:	Receiver. (IGI-Beliefs and Practices)

While the action research was ongoing, Teresa showed changes in the way she taught and how she expressed her ideas during group discussions. During this stage, she used different teaching strategies, especially using activities. These activities allowed students to do things that captured their interests and led them to participate actively in the learning process. In group discussions, she would now elaborate, for example, on the issue of the role of a mathematics teacher. She said that the teacher is nowadays a facilitator of learning and that the students are not just "receivers", rather, there should be a two-way learning process.

> Let's say, you have to give the students a problem, right? But on that problem, they will solve it, you would help them, for example, through your questions, giving some examples... We just give and take. Unlike before that it should all come from the teacher. (FGI-Beliefs and Practices)

There was also variety in her use of visual aids especially when she used problem solving and practical work as the teaching strategies. Most of these visual aids were also used by students, and not simply for demonstration. Some of these visual aids were even reusable (for example, the geoboards and the number-line models).

Teresa's eagerness to learn was also observed in the way she managed to come up with good activities for her students. She was once seen consulting the head of school about a certain activity which she was willing to try in her class. She also consulted the researcher about her planned activities. She would sometimes share these activities with other teachers in her department.

Her commitment to this study was also noted. She volunteered to take care of compiling the activities for the whole group and would comply with all the requirements that were agreed upon by the group like completing diaries, and implementing the activities.

> For me that one on—we agreed that we'll do the activity although Ate Flor won't be around. That's what happened to me. I did it even Ate Flor was not around, no one was observing, I did some activities. And then when she arrived, I explained it to her. (Cycle 2 meeting)

It is interesting to note that with or without an observer in her class, Teresa claimed that she would still make changes in her teaching.

It appears that Teresa's involvement in this study resulted in professional growth. In her personal assessment, she indicated that her pedagogical knowledge was enhanced. Statements such as: "I realized there are other techniques which the students are enjoying" confirmed this finding. Her teaching practices had also changed. As an example, she would now include student activities using manipulatives in her teaching. Her beliefs, too had changed. She now believed that the role of a mathematics teacher is that of a facilitator and that in the classroom there should be "give and take" of knowledge between the teacher and the students.

Alex

Personal view

Alex talked about the changes he made in his teaching and one of these was the confidence that he gained from his involvement in this study. After the first cycle of the action research, he narrated:

Alex:	The one I liked in my involvement here?
Researcher:	Yes?
Alex:	That one where I got the courage, as if I got this... *Tiwala* (Confidence)... Because last year when I heard that somebody will observe—(laughter from the group).
Cindy:	*Kinakabahan na!* (So nervous!) (laughter again). (Cycle 1 meeting)

Alex appeared to value the confidence he gained for he made a similar statement at the last meeting. This was when each of them was asked to give a short statement on what they thought about the impact of the project on themselves.

Alex:	Ah, I gained confidence.
Delia:	My observation is right.
Alex:	It used to be, remember, I told you that when I learned that there's a visitor coming, I would go ahead of you.
Cindy:	He would disappear! (Cycle 3 meeting)

The observation of the head of school, Delia, and his behavior of not "disappearing" anymore when there was an observer, confirmed the confidence that he claimed he now has.

Another change which Alex said was brought about by his involvement in the study was the way he now teaches mathematics.

> Now, it's different. For example my past lesson. The given are the actual answers, something like this, see, that's already an answer. What they will do—why are the two angles congruent? They will be the ones this time to analyze... Now I'm using group work. Sometimes there's an activity and the students had their participation. (Alex, FII-Teaching and Changes)

In these statements, he was referring to his teaching style in the past when he monopolized the talking—trying to explain almost everything. He has started to involve students, sometimes in groups, like in the analysis of the theorem. He emphasized these changes in his teaching again in one of the group's discussions.

> Really, it used to be, when I discussed it [complementary and supplementary angles] I used to teach it, it's just by computation. (Cycle 3 meeting)

It emerged that he learned other ways of presenting a lesson and he mentioned this again in the final interview.

> It used to be when we solve it, when we find an answer to the problem it's by computation. Now it can be done through an activity. No need to use computation, you can solve it. You can find the equation by using the activity. (FGI-Beliefs and Practices)

He seemed to have changed his view in that certain topics can be taught in a different way, not just by computation, by which he meant the topics were taught in an abstract and symbolic way.

As a result of broadening his teaching strategies, he learned to make plans that led him to study more and to appreciate what had been achieved.

> Because we're able to think of a way where students can easily pick it up... Because I learned that technique. I didn't know that before. (Cycle 1 meeting)

Here, he was sharing with the group that in planning his lessons, he learned how to think of ways to make it easier for students to understand. In the next meeting, he made a similar statement.

> In my case, instead of how it used to be, just like what Art said that you just read the book and discuss it. Now, for example, we read it then we will include an activity. You would think of an activity. You noticed that we do ask. As if it's new, as if there is—the result is just the same but the students enjoyed it. You also observed it. (Cycle 2 meeting)

He claimed to have learned techniques in teaching that enabled his students to easily understand. In preparing for his lessons, he also tried to think of an activity that he perceived to be enjoyable for students.

Writing diaries seemed a difficult task for Alex. Although, effort had been made by the researcher and the department head to convince him to write his diary, he was not able to do so. Since keeping a diary is a personal and a private matter, Elliot (1991) suggested that there should be no compulsory collecting of diaries. Hence, little information was gathered about his reflections on the class activities that he used and also about his comments in meetings. He did have one diary entry though, completed during the last meeting. Below were his comments on his roles and contributions and his feelings about his interactions with the group.

> In this meeting I shared about my activity, the reaction of the students and participation... In this group I can say *na masigla o masaya kaming lahat.* Very cooperative to each other, *para madaling matapos ang* activity. *Humihingi ako ng* suggestion *kung ano ang nababagay na* activity *sa* topic . (In this group I can say that we're all happy. Very cooperative with each other so an activity could readily be finished. I asked suggestions on what activity is suited to a topic). (Meetings diary)

What Alex shared here was not only his feelings but also his observations on the successful collaboration of the group.

School head's view

The first time the head of school saw Alex teaching was on the video taken at the early part of the study. Based on the video, she wrote comments such as these: clear explanation of concepts, no generalization and it was more of a teacher activity. On her second observation during the action research, she made this comment:

> Lesson was presented with an activity where everybody is involved. It was well sequenced and the students were able to grasp the concept through an activity. (Delia, Monthly observation report)

The school head here was referring to the *Guessing Game* activity on linear functions. She really noticed the changes and told the group about this in one of the meetings.

Delia:	Ah, you now have it, that's very good. He now has the confidence. But, there's a big change, Alex, I observed it. When you finished, I discussed with Flor. I said on video I noticed your shortcomings and that time when we were present.
Researcher:	We were so many.
Delia:	We were really that many, remember? There was a big difference. As if there was this big gap from that of the first and this latest one... It was good—you surprised everybody. Even me because the first time I saw you through video. And to think I wasn't there. (Cycle 1 meeting).

Delia observed a great change in Alex's confidence in teaching mathematics. This class observation seemed to impress her that she reiterated this in the next meeting.

> There's already a big improvement, in Alex's case... When there was that video we were not there yet. But when we observed, there was this big difference. (Cycle 2 meeting)

No observations on how Alex participated in group meetings was mentioned by the school head.

Peers' view

When the group observed Alex in one of his classes, comments about his confidence were made: "Oh, so Alex has a sense of humor in teaching." One of his peers shared with the researcher that she really observed a change in his attitude especially on his commitment to teaching. He was now attending all his classes, some of which he had missed in the past.

Researcher's view

Teaching strategies and attitudes towards teaching are some of the noticeable changes in Alex. These changes were noted during class observations and discussions in meetings.

In the early part of the study, interviews with him did not reveal a great deal of information. He seemed hesitant to answer, much less to elaborate on some of his answers. In group interviews, he did not say a lot. With regards to his teaching, it was observed that his usual way of presenting a lesson was through exposition. Chalk and board were widely used to explain the concepts and for students to show answers after seatwork. On one occasion, a student was requested to write some notes on the board taken from a book. The rest of the students had to copy these into their notebooks. In general, it was a teacher-centered classroom environment.

Changes in Alex's attitudes towards teaching and in presenting a lesson were noticed during the cycles of action research. He showed confidence in teaching and this was evident even when the teachers from the mathematics department and the head of school observed one of his classes. On this occasion, the researcher observed that, in his lesson on linear functions, his explanation to the students was natural and confidently expressed.

Although, he was the one who was less motivated to look for activities on his own, Alex seemed happy to try them once they were available and when there was not a lot of teacher preparation required.

In group discussions, he would still not say much, but on occasions would assert himself. In one of the group meetings he was asked what he liked about his involvement in this study. After giving his answer, the discussion went on like this:

Researcher:	Now, what is it that you don't like Alex?
Alex:	Still on what I liked!
Researcher:	Oh, yes! (laughter from the group)
Cindy:	Still many?
Teresa:	Really many! (Cycle 1 meeting)

This openness to express his ideas, although very rarely, was noticeable especially to his peers and to the researcher.

As a whole, comments from these different people and from his personal view indicated that there was considerable professional growth due to his involvement in the study. This was reflected in his teaching strategies. However, it was observed that, in some ways, his attitudes towards involvement in this study did not change a great deal. He was neither motivated to prepare activities for his class or write entries in his diary.

Art

Personal view

Art's account of his involvement in this study based on his diary entries, interviews and statements during group discussions revealed that he perceived positive changes in himself that would enhance his teaching of mathematics.

In the early part of the study, Art acknowledged learning something from his involvement especially through watching himself on video.

Art:	The first thing, when there was this video session, you saw yourself. So, this is how I teach, that can be changed. (Laughter from the group.) That's true, yes... Oh, you would be frustrated . So it's like this, I was wrong—it should be add the numbers. I didn't change it.
Delia:	You are correcting it based on what it should be.
Art:	You saw it, you saw me, oh, that's it! I have something to change.
Delia:	You realized it?
Art:	I realized it. Oh, there is still something to change in me! (Laughter from the group.) I saw myself when I was already teaching that, I did like this. Sometimes it's funny and also frustrating when I saw myself... Oh, because ma'am I saw my mistakes, remember? It should be corrected, it should be corrected, then it was corrected. (Cycle 1 meeting)

Here, he seemed to realize that there could be changes to his teaching of mathematics particularly relating to his knowledge of the content. Before watching the video, he was not aware of this. In preparing his lessons, he now says that he is doing it quite differently—always thinking of students' learning.

> Not like before that you just read the book. Oh, it was just like this, that was it. No other idea, just up to there. But now, at least you would think. What else would I do, other ideas to encourage the students to learn math. Not like before that it was just up to there. Now, there are changes, so many changes. (Cycle 2 meeting)

It is apparent that Art realized that he could come up with his own ideas to encourage students' participation, not totally relying on books.

After every meeting, diary entries were used to record their comments on their roles and feelings of their involvement in the project. In the three diary entries that Art gave to the researcher, he wrote about his role and contribution during meetings, saying that he did the following:

> Make suggestions and comments on the topics that were discussed. Share my negative and positive comments about the end of the first cycle of our professional development. I shared my views and comments about my attitude now in teaching. (Meetings diary)

It was observed that Art always said something on topics that were discussed. It was also observed that he would be the first one to deviate from the topic. He also shared what he felt about group meetings.

> It's a nice idea working and sharing with them. It's a nice feeling interacting with the group. The responses and suggestions were helpful not only for development but also a great help in our profession. The group was cooperative and they shared their views on the activities that they have made. They also commented on the success of the project. (Meetings diary)

His statements seemed to indicate an appreciation of having the chance to interact with the group which he found to be helpful in his professional growth.

In the final meeting, each of them was requested to make a short comment about the impact of their involvement in the study. Art's answer was this: "More commitment to students." He could mean here that he now tried different teaching strategies with his students and had become more observant of their reactions. He may have observed that there was so much to share with his students and this would require more commitment to them.

Head of school's view

Delia, the head of school observed how Art taught in the early part of the study through the recorded video. Below is an excerpt from her observation report.

> The teacher presented the lesson of multiplication of radicals through induction method. Sufficient examples were given which enabled the students to generalize... Maximum participation was not observed... Examples given are of the same kind. (Monthly observation report)

She made further comments about this method of teaching in a meeting that was called to give reactions to the lessons that were viewed on video.

> In the class you would notice, Art even had an individualized instruction. That was one thing I noticed about him... He moved around, it's really like this, like this, like this. See, as if you have individualized instruction there, remember? Follow-up of that, that's really needed, although what I said that's my type for—oh, if you have the energy, it's just right to be that way because they're so many inside, that's it. (Reactions to video)

Delia observed that, despite the large class size, Art spent time helping students with their individual needs. Little further comment was made by Delia about Art during the action research except for his honesty to accept that he still has this need to enhance his teaching of mathematics.

Delia:	Oh , how about Art?
Art:	Eh, ma'am, for me-
Delia:	Why are the students like that, what's the defect [referring to the lack of students' participation]?
Art:	Me! (Laughter from the group)
Delia:	What will you do now?
Art:	Next time-
Delia:	Anyway, Art is very honest. (Cycle 2 meeting)

The openness of everyone to share with the rest of the group about their needs was observed, as in the case here shown by Art. This was a rare situation of a teacher admitting his weakness openly. Perhaps, the rapport that was established within the group was helpful.

Researcher's view

Based on the researcher's observations during meetings, in the classrooms and during consultations regarding the activities, there were changes that were noticed about Art's teaching and attitudes that could be considered part of his professional growth.

It was observed that, in the early stage of the study, Art's way of teaching mathematics was mainly by the use of chalk and board. Furthermore, he did most of the talking, although on a few occasions he would use some materials to aid his explanation. The participation of the students centered mostly on answering closed questions and on the assignments and seatwork where they were allowed to show their solutions on the board, sometimes one at a time. He would also move around the class monitoring students' seatwork.

The use of materials was observed at the early part of the study which was primarily to demonstrate principles, but were not used for students to manipulate. In one of his lessons, he borrowed two face towels from his students and showed them that the bigger one would represent the positive and the smaller one the negative, thus the answer would be positive. This was followed by showing two coins to illustrate that a positive and a negative is zero. Also, four boys and four girls were asked to stand up and he explained that this shows that the result of +4 and-4 is zero.

On one occasion, a contest was used as a closing activity where one representative from the boys and one from the girls went to the board and answered the exercises while the rest of the class just watched. Art affirmed that he said he was using different ways in discussing the lessons even when no one was observing his class. In one of the meetings he illustrated one of the methods he used in class.

> Because, first thing, there on using radicals. At first I did it there because the students really find it difficult to solve equations. They don't know what to do. I didn't do—because there are two things. First five pesos, two five pesos. If I have five pesos here, are they the same? There are those who said the same, one is five pesos and the other one is five pesos, so the same. Now, different ideas are presented until the students are ready for the lesson... I'm thinking that, what's this? Of course I would count the boys and the girls. Simple factoring only, that's on multiplication, remember? That one with the exponent, how would they analyze

> that there's an exponent? For example, I'll call two boys here, the big ones in class. The small ones on top, that would be the exponent. (Planning meeting)

Based on these transcripts, it could be said that even before the action research, occasionally he used a variety of techniques, during his lessons. However, the researcher observed that the way Art used the materials in the classroom for students' understanding seemed problematic.

During the action research, it was observed that Art made changes in the way he used materials for teaching and how the class was managed. Materials were used by students as a springboard to discuss a concept or a principle, such as the algebra tiles for factoring trinomials. Group work was also used. He would also plan activities and would try them in his class like the outdoor activity to practice skills on factoring expressions.

Art's openness to consult the group about the activities to use or how his lesson was to be presented, was noticeable during meetings. One time he made this statement:

> Ma'am [referring to the head of school], could it be for example, I have started in quadratics, then I would go back to the Cartesian coordinates? (Cycle 1 meeting).

Here, he was trying to confirm from the head of school if it would be a good idea to discuss Cartesian coordinates after he discussed quadratics. Art often consulted the researcher about the activities that he was considering, especially those which were not taken from the resource materials, but from his ideas. He would also observe the class of the department head, or would ask her or the researcher to demonstrate how an activity may be used in class. This occured when he felt that the activity he tried in one of his classes did not turn out okay.

It appeared that there were a lot of positive changes that occurred in the way Art was teaching and interacting with the group. He was the one who would try his best to develop his own mathematics activities. However, he seemed to have a need for discussion with colleagues about how he would present the activities in class. He saw this as enhancing his presentation and lessening the confusion or misconceptions of his students.

Cindy

Personal view

A description of Cindy's professional growth is based on the results of interviews, the ideas that she shared during meetings and on her diary entries.

She acknowledged that there had been changes due to the use of activities in class and the closeness which had developed within the group.

Cindy:	One good—we're exposed to the activities. Another thing, like this happened.
Researcher:	Camaraderie?
Cindy:	Yes. (Cycle 1 meeting)

A similar feeling of camaraderie among the participants was reported in the action research study conducted by Herrington et al. (1995). In addition, because of the experience, she believed that her strategies in teaching had changed. She described these changes in one of the interviews.

> As though, it's not chalk and board everyday. Yes, it's not everyday anymore, at least once a week we had an activity if possible. Sometimes twice. Then as if it's not enough that you know only that much. You need to think of a way to approach it, especially if it's an activity... Lots of changes had been made. Now, at least its the students who did most of the talking, although sometimes I do if they couldn't really answer it. I would just give supporting questions, something like that. They no.. really talked most of the time especially in *Mangga* (Mango, a name assigned to a group of selected Year 3 students with good academic standing). (Cindy, FII)

Cindy described the major change in her teaching of mathematics in terms of the strategies that she used. She supplemented the use of chalk and board with students' activities. In some meetings, she would share with the group that she was now sensitive to students' reactions and this gave her ideas on how concepts could be taught.

> That one on—I also realized it just yesterday. I mean, before, the way you teach proving was so difficult. Those symbols of angles, how you got it. But when we did the similarity, as what I said a while ago, it was them who used those symbols. Oh—this would be the angle. Ma'am, you did it the short way. Of cour e, that's why we have symbols, what would you do? I observed that they themselves are using, ah—angle ABC equals angle, like that, like that. Angle this is similar to. As if, those statements in proving , they're doing it unknowingly. (Cycle 3 meeting)

She seemed to have sensed that teaching similarity, symbolism and proving in geometry could be done informally and with the participation of students. Her comments on her roles and also the feelings about her involvement in the study were recorded in her meetings diary. For her roles and contributions, she claimed that:

> I initiated the discussion by asking the demonstration teacher about what he did during the lesson and I asked for clarification and made observations. I would say that I participated actively in the discussion. I shared my ideas like everybody else. We have a line of open communication. I led the discussion in cycle 2, shared findings and observations and give reactions to their comments. Initiated the discussion by reflecting on the third cycle. Gave the views on the topics. (Meetings diary)

It appeared here that she saw herself having two main roles on the study. Firstly, as an active participant by sharing her ideas and secondly, as a leader of the group by initiating discussion.

Also, in the same diary were records of her feelings about her interactions with the group.

> The interaction among the group was great, because everyone on the group gave their own reactions, they were able to share their own ideas to one another. We were able to give our ideas openly with the group, it is as if we were just sharing stories among the group. Our interactions is an open line. We can give our opinion without feeling awkward. We can say what we feel without feeling that we are hurting the other member of the group. There was an open discussion. (Meetings diary)

It is interesting to note that in all her statements above, she mentioned her feelings about "open" communication. She seemed to be comfortable with this kind of discussion which was done in an informal manner and in which everyone showed eagerness to share their experiences and views.

In the final interview, when asked to describe in a short statement the impact of her involvement in the study, this was her answer: "Improvement. For me it was an improvement because of the project." Since she assessed her involvement positively, this could be the reason why she was showing hints to continue what she had been doing.

> That's it, but then vacation [long summer vacation] is approaching, so I'll go ahead with it. I'll prepare it this vacation so that when the time comes, I'll just pull it, I don't have that problem. Because it's difficult if you're not ready. (FII-Teaching and Changes)

Here, Cindy appeared to have identified the problem of lack of time to prepare the activities but was still motivated enough to prepare these activities in her free time.

School head's view

The school head had once observed Cindy in the classroom. This was before the start of the action research. In Delia's observation report, she wrote:

> The teacher presented the lesson after discussing the assignment. It was done systematically and associated with the concept previously learned by the students. Exposition method was used. Mastery of the lesson by the teacher cannot be questioned. Some prerequisite skills were not taken during the review. (Monthly observation report)

The school head observed how Cindy used exposition as a teaching strategy and commented on her knowledge of the particular content in mathematics. Furthermore, on her observation report, she listed some suggestions. One of these was about assignments indicating that in order to save time there is no need for discussion if students already have the answers.

Delia also made some comments on the way Cindy taught after she viewed the video.

> Delia: That's it. So, at least in other words, you reviewed simplifying radicals, but then it seems not enough... So that's what we saw, remember? There was this commotion and guessing. Your review was okay but seemed not enough. So which portion, if that was the

defect, what was your defect there as a teacher? What do you think have you missed?

Cindy: I was not able to identify that area. I should have reviewed them about it before I proceeded. (Reactions to video lessons)

Here, both Delia and Cindy seemed to reflect on how the lesson was presented and tried to identify what could be done to improve future presentations.

During the action research, Delia did not make specific comments on Cindy's professional development. However, she seemed to see the potential of Cindy when she suggested her involvement as a facilitator in the workshop with the teachers in the division level.

Researcher's view

The professional growth of Cindy during her involvement in this study was based on class observations, interviews and her statements during meetings. Being a newly appointed head of the department, she formed a close working relationship with the researcher. She would openly discuss some of the plans for the mathematics department and the action research project.

In the early part of the research, Cindy would mainly use exposition which she handled quite well. Her good knowledge of content was observed. The students' role mainly involved listening and they would participate by showing on the board the solutions to assignments or to seatwork.

During initial interviews and group discussions, she seemed to be the one who was at ease in expressing her ideas and would elaborate on them when requested to do so. In the planning meetings, she shared her ideas and often initiated the discussions.

As a new department head she was always in consultation with the researcher. Talks about inservice courses that could be conducted to help the group carry out the plan is one example. This idea would then be presented to the group for discussion. She was also willing to take responsibilities, such as being one of the facilitators in the workshops that were conducted, both the school based and the division level ones. She was able to manage well in this task.

Her commitment to this study was noticeable as she would follow-up the collection of activities, diaries, and lesson plans of her colleagues. She also showed willingness to help other mathematics teachers by sharing with them the activities that she came across while looking for activities that she could use in her class. She would also demonstrate to the teacher how the activity could be used in class.

It was noticeable that Cindy's involvement in the study had a positive impact on her both as a classroom teacher and as a department head. She acknowledged to have learned from the exposure to the use of activities that led her to change her teaching practices. She was no longer using chalk and board that often. She also showed active involvement in the study by willingly accepting different roles such as participant and initiator in group discussions.

Bert

Personal view

In the interviews, discussions during meetings and in his diaries, Bert indicated the gains he had made from his involvement in the project. Some of these relate to the confidence that he developed and the strategies that he learned in teaching mathematics in Year 4.

Researcher:	In your case Bert, what happened?
Bert:	Great change... For me, great change happened. As I said before, mostly I didn't have activities. I just like to talk... I really just talked, and didn't use something like that [activities, for example]. But now I'm in fourth year and then you're here, you helped me. What happened to me, ah, as if my *kaba* (nervousness) was gone, right? Ah, I can manage this, Ate Flor is around. As if it was like that, my inhibition was gone. Ah, I can make it. Maybe if there will be visitors, I can manage. I felt this way. (FGI-Teaching and Changes)

Bert felt that his involvement in the study contributed much to his confidence as illustrated above. He seemed to attribute this confidence to his experiences in using different strategies and the support that he got from the group.

> But then there are so many ideas now that come to my mind... Yes, just like what I did on draw lots [an activity to practice skills on solving logarithms] which I developed myself. (Cycle 2 meeting)

Bert's involvement in the project enhanced his creativity. However, creativity was not the only gain. When he was asked to give a short statement about the impact of his involvement in this project, he referred to his newly-gained interest of acquiring knowledge through reading.

For me, it seemed I became a wide reader! (Laughter from the group). I became a wide reader, it seems. When I arrived home, I would always grab a book. (Cycle 3 meeting)

His becoming a "wide reader" could be argued to be not necessarily a result of the impact of the study. It could be his need to refresh himself of the content required in Mathematics 4. Nevertheless, this in itself would appear to be a positive change in attitude although may not be attributed to his involvement in the project.

He also said that he became sensitive to students reactions and this enabled him to learn something from them.

Researcher:	Before as if you mentioned in one of our discussions that we are *giver* of knowledge. Up to now is it still the same? We are the *giver* of knowledge to the students and-
Art:	No. They need to be the receiver now.
Bert:	No. A student could also give you knowledge, right? (FGI-Beliefs and Practices)

Bert was arguing that students also have knowledge to share with their teachers.

In his meetings diary which he completed while the study was ongoing, he wrote about what he did, as well as about what he felt concerning his interactions with the group. Referring to his roles and contributions, he wrote:

I gave some comments and suggestions based on the observed teacher. Like the effects of the facilities, etc. I mostly was attentive especially on Teresa's demo [demonstration lesson] since it focused on circle. I'll use that also in my lesson. (Meetings diary)

It is clear that he was willing to accept new ideas from his colleagues and to use these ideas in his class. In another diary entry, he wrote about what happened in the meeting.

> I was listening to my companions' experiences, suggestions, weaknesses and some strong points in teaching. They shared what they want and what they do not want of course in the teaching. I contributed or shared also on the things that I do not want and we all agreed and that was the preparation of the activity. (Meetings diary)

He pointed out here that the group had difficulty preparing the activities. However, in his next diary entry, he appeared pleased about suggesting one of his own activities.

> In our second cycle meeting, we talked about the activities that we did. About my activity, I'm happy because I was able to come up with an idea [of an activity] which turned out okay. It even turned out better when I consulted this to Ate Flor. (Meetings diary)

It is apparent that there were consultations with other members of the group. Bert believed that his colleagues were of great help in his learning. This confirmed the finding of Holly and McLoughlin (1989) that many teachers considered their colleagues to be the source of ideas that were helpful in their teaching.

> I shared my activity with the group, regarding the good points on the activity and also on the weak points. *Kaya sa akin parang nasa akin ang role na sila'y matuto at siyempre katulong din ang mga kaguro ko sa pagtuklas pa ng iba pang paraan.* (So, for me, as if it's my role for them to learn and of course with the help of my colleagues in learning other ways). (Meetings diary)

His statements reflect the view that his teaching benefited from the project for he was able to share his ideas and to listen to other people's ideas.

Bert also wrote in his diary his feelings about his interactions with the group as listed below.

> I feel comfortable since all of us were free to talk, *walang kinatatakutan* (no one to fear), we're discussing/interacting with the group just like playing, with an output as the result. Of course, good result. (Meetings diary)

Bert observed that everyone was free to share ideas which resulted in good outcomes. This feeling of being comfortable in sharing his ideas was again mentioned in one of his diary entries.

> I feel free and comfortable in sharing with the group; no fear in sharing experiences and it seems our meeting is just like *kuwentuhan at talagang walang nahihiyang mag-share sa bawat isa* (telling each other a story and really no one was shy to share with anyone)... I feel comfortable in sharing with the group, no hesitation; *talagang parang nagkukuwentuhan lang kami* (as if we're just telling each other a story). (Meetings diary)

It is apparent that when the discussion was like "telling each other a story", Bert felt comfortable in sharing his ideas. His entry on his last meeting's diary confirmed how happy he felt about being involved in the project.

> My feeling was easy, happy and confident. And also, *parang wala nang problema sa math subject* (it seemed there is no more problem in math subject). (Meetings diary)

All his statements described his feelings about being comfortable to share ideas with the group. This could be the reason why his eagerness to share his ideas during meetings was noticed by almost everyone.

Head of school's view

Delia's view on Bert's professional growth was based on her observations during the meetings and the two classroom observations she made, one of which was in the early part of the study and the other one during the implementation of the action research plan. In relation to her first observation, she made the following comments:

> Review of functions and its kinds were taken before the presentation. However, this has no relevance to the topic presented. Lesson was presented logically but mastery level was not attained. Good motivation. With mastery of subject matter. Did not allow the students to enumerate the procedural steps which will lead to generalization and clarification of concepts. (Delia, Monthly observation report)

These statements could be interpreted to mean that, although Bert showed mastery of the subject matter and was able to motivate students to participate, his approach still needed more thought. The relevance of the review to the main topic needs consideration as well as maintaining students' participation.

During the second cycle of the action research, Delia again observed Bert in one of his classes. This time she commented:

> An activity approach in presenting a lesson was used. Cooperative learning was exercised with the use of calculator where students were asked to answer a puzzle that will lead to the development of the concept. There was maximum students' participation and students' interest was maintained. Time management [referring to the weak points]. (Delia, Monthly observation report)

Here, Delia was able to observe Bert using different teaching strategies. Except for the last statement, his presentation of the lesson seemed to impress her. Another change which Delia observed about Bert was his participation during meetings, although this observation described all of them.

> So, really your format is different. At first, you didn't say anything, that is what I observed. (Laughter from the group). So quiet! No matter what you say, as if it was only me and Flor who talked... Now, we can't, what's this? We just keep on asking questions. That's it! You haven't ask Bert yet and he would talk. It used to be, they won't talk, remember? (Cycle 3 meeting)

Delia here was referring to the eagerness of everyone now, particularly Bert, to share their teaching and learning experiences and their views. It was apparent that her observations on the professional growth of Bert focused on his teaching strategies and his attitude towards participation in professional development activities.

Researcher's view

Being his first time teaching Year 4, Bert often consulted the researcher, both on mathematics content and teaching strategies. Transcripts of interviews and meetings in the early part of the study revealed that Bert would not talk a lot and would participate only when asked, but would not elaborate. His lessons, based on classroom observations, could be described as 'teacher-dominated' discussions. He did most of the talking and the students' participation would just be confined to the discussion of assignments and seatwork. Answers of these assignments and seatwork were mostly done by the students on the board. There was one time that he started the lesson with a puzzle. Students were told to transfer one stick to make this statement true: l-lll = ll. Unfortunately, Bert did not take the opportunity to provide students with materials to solve the problem and they were left to imagine a solution.

When the group started to try out activities in their respective classes, Bert showed eagerness to join in. He would even think of his own activities, if he felt that, for some reasons the ones from the PASMEP resource book could not be done. He would complete his diaries and gave copies of the activity sheets for compilation.

His willingness to learn and openness to new ideas could be observed during meetings. In one of the meetings, one of the teachers suggested that there should be a rotation of teaching loads every year. His comment was:

> It's a good idea if we have that cycle in teaching. For example, me, I could go to first year, then second year. As, if it's not stagnant. (Cycle 2 meeting)

He showed willingness to change the year level of mathematics he would be teaching for he perceived this to refresh his knowledge. Perhaps, he wanted to be familiar with the mathematics content in every year level.

Bert photocopied the written comments made by the researcher on the activities that he tried. He said that these comments gave him an idea about what could be improved in future lessons. Also, he would often talk to the researcher about the activities he planned to use and about some refresher lessons on specific topics.

> In my case, I always discuss with Ate Flor... If there's a problem, Ate Flor, could this be? Sometimes I would give her a plan. That competition, draw lots, it's another style, that was my idea. I said, Ate Flor could this be? For example, they're in four groups, they would run then get it. They would choose who would answer it. She said, that's okay. (Cycle 2 meeting)

The initiative of Bert in preparing his own activities is apparent here. He would often described his plans to the researcher before using these in his classes.

techniques in teaching mathematics that could be enjoyed by her students. This realization could be one of the reasons why she was motivated to vary her teaching strategies. Changes in Teresa's teaching practices and beliefs were also observed as a result of her participation in the study. For example, her inclusion of activities using manipulatives and the change in her belief that the role of a teacher is that of a facilitator of learning.

In the case of Alex, comments from different people appeared to indicate a considerable professional growth resulting from his involvement in the study. He made variations in his teaching strategies such as the use of group activities. The major change that almost everyone in the group had noticed, and which he admitted to have gained, was his confidence in teaching mathematics. Although, he appeared to have difficulty in finding mathematics activities suited to his class, he showed willingness to use these activities when the prepared ones were given to him.

A lot of changes were observed for Art as a result of his participation in the study. There were changes to his teaching practices resulting in the use of varied teaching strategies. He also tried to develop his own activities, like the outdoor activity for factoring trinomials. He appeared to welcome suggestions from colleagues on how his presentation of the lesson could be improved.

Cindy's active involvement in the study was observed. She acted as participant and initiator in group discussions. She claimed that her participation in the study had a positive impact on her as a department head and as a classroom teacher. Furthermore, she acknowledged that her experience in the use of activities resulted in changes in her teaching practices, moving away from mainly using the chalk and board.

Bert's changes to his teaching practices and to his beliefs were observed by the different people involved in the study. In the past, he preferred to just talk in front of the class. As a result of his involvement in the action research project, he has started to include hands-on activities in his teaching. Another change that was observed was his confidence in teaching and his expression of ideas during group meetings.

Although there was professional growth that was observed in each of these participating teachers, there were still some aspects which did not change significantly. There were still those who found difficulty in managing time for classroom activities and finding the motivation to prepare the activities. But it appeared that all of the teachers made positive changes to their practices and attitudes towards teaching mathematics. The changes that were observed across the five teachers, including the department head, will be discussed further in the next section.

Changes in pedagogical knowledge, practices and beliefs

The changes made by each of the participating teachers were described in the preceding section. In this section, changes in pedagogical knowledge, practices and beliefs will be discussed more generally, comparing the situations before and during the action research. While it is apparent that pedagogical knowledge, teaching practices and beliefs are interrelated, for the purpose of analysis, these constructs will be considered separately.

Changes in pedagogical knowledge

Teachers' pedagogical knowledge here refers to their knowledge of general instructional strategies (Ormrod & Cole, 1996; Shulman, 1987). For this study, it will focus on knowledge about the six teaching strategies described in the Cockcroft report (Department of Education and Science, 1982). These are the use of exposition, discussion, consolidation and practice, practical work, problem solving and investigational work. The teachers' knowledge on these strategies will be discussed in two stages: before and after the action research.

Pedagogical knowledge before the action research

Interviews revealed that the teachers were knowledgeable in the use of exposition as a teaching strategy. They used this strategy to explain assignments, to give examples and to introduce concepts. They said they used this strategy irrespective of whether or not there was an observer in the class. They talked about this during one of the meetings.

Teresa:	Other strategies. What we are using, it's always the same.
Cindy:	That's it, just teacher exposition. You can't.
Researcher:	What else did you use, when I didn't observe you?
Cindy:	Only that, right?
Teresa:	Yes, because that's the only one. (Planning meeting)

These teachers seemed to inform the group that they were using exposition all the time because this was the only teaching strategy that they knew. As observed, exposition for them would mean that the teacher would be the one to talk in front of the class most of the time, sometimes with the use of chalk and blackboard.

The teachers' knowledge on the use of discussion as a teaching strategy was mentioned in the interview:

> For example, on the laws of exponents. If I can't finish it all, I discussed simpler laws altogether and the complicated ones separately. So, that's it, we just divide (the topic), then discussion. They will solve, then seatwork, discussion. Discuss and solve. So, before we reached the complicated part, they had an idea of it level by level. (Cindy, III-Teaching and Changes)

It appeared here that discussion for Cindy would mean explanation, in this case involving laws of exponents, and the students' participation would be solving the exercises. In the Cockcroft report (Department of Education and Science, 1982), discussion was described as more than just a teacher explaining concepts, rather, there should be an oral communication between the teacher and students or between the students themselves requiring more than short questions and answers. However, there was one occasion where Cindy showed knowledge of discussion as a teaching strategy when her topic was simplifying radical expressions. She asked a series of questions requiring students to elaborate on their answers.

Bert indicated a familiarity with the use of problem solving as a teaching strategy when he said:

> I gave puzzles, games. They liked it, they learned something from it. For example, the short cut method of getting the sum of numbers from one to ten by getting the pairs and multiplying on the next number. Something like that. Bert (III, Teaching and Changes)

He claimed that he would always gave this type of activity in the review part of his lessons.

The consolidation and practice as a teaching strategy was mentioned, but there was no elaboration. However, knowledge about this strategy was reflected in their lesson plans (refer to Appendix S for a sample lesson plan). There were 'Generalizations' and 'Applications' portions in their lesson plans and when implemented in classes, could be interpreted as practice and consolidation.

The teachers' knowledge of practical work and mathematical investigations did not come out in the interview nor was it reflected in the way they taught mathematics.

It was apparent that before the action research, the teachers' knowledge of teaching strategies was mainly about the use of exposition. This knowledge of exposition was reflected in the way they taught. This means that they would talk most of the time and that students' participation was minimized. Usually, students would be asked to show on the board, answers to assignments or practice exercises, without having to explain or support the answers. Or else, students would be asked to give answers to mostly closed-type questions, requiring single word responses.

Pedagogical knowledge after the study

Changes in pedagogical knowledge by the teachers were noticed through interviews and class observations. They acknowledged that before the study, most of the time they used blackboard and chalk and now they have learned something else. Each of them said something about these changes on different occasions.

> Before when we didn't use activities, we just used chalk and board and sometimes manila paper. But those games, puzzles, we didn't use those. But when you came there were changes. Not only in myself, but with the students, too. On the students, we showed them that mathematics is not difficult. (Teresa, FGI-Teaching and Changes)

Teresa was describing the changes she made as well as those made by her students. Cindy made a similar statement.

> At least I've learned other strategies aside from chalk and board, that's one thing. And also there's an inclusion of humor in mathematics. Not so much now that the students would think of me, *naku, math yan, patay!* (oh, my that's math, scary!). It was something like that usually... Now, it's not chalk and board everyday... Lot of changes had been made. Now, at least it's the students who did most of the talking, although sometimes I do if they couldn't really answer it. I would just give supporting questions, something like that. (Cindy, FII-Teaching and Changes)

It appeared that the use of other strategies resulted in changes in both the teachers and students. This was also the observation of Art.

> There's a big difference. It was good. Before, it was blackboard and chalk. Unlike now, I could create an idea out of something on the environment. Before they were involved, but less and individually. It's really individually, unlike now there's groupings and individually, so there's a big difference from now and before. (Art, FII-Teaching and Changes)

Teresa, Cindy and Art explicitly stated that the use of blackboard and chalk has lessened because of the inclusion of hands-on activities. Alex and Bert did not mention chalk and board, rather they talked about other changes made to their teaching.

> Now, it's different. For example my past lesson. The given are the actual answers, something like this, see, that's already an answer. What they will do—why are the two angles congruent? They will be the ones this time to analyze. Now I'm using group work. Sometimes there's an activity and the students had their participation. (Alex, FII-Teaching and Changes)

Alex was describing how he changed his questioning techniques as well as class organization. Specifically, he mentioned about group work and the use of activities. Bert made similar statements:

> If we would compare what happened before and now, its more okay now because my lessons had improved. Because mostly, for example I have puzzles, activities using the geoboards. You could really compare before and now. My style before, as if I just really wanted to teach—it's only me who is talking then the students are doing the exercises. This was what happened: teach, then exercises for students, then give test. These were mostly what I did. Even though I was teaching in first year before, that was what I did, too. Now, you could see the big improvement. There are groupings and after that, the students will discuss it. Then on the students' discussion, I know those, too, but at times I learned from their discussion. My knowledge increases based on what they discussed. I would say: You're right! Yes, that can be. Yes, it's right! (Bert, FII-Teaching and Changes)

Alex and Bert became aware that group activities could be used in class and that such activities could contribute to an increase in their knowledge as listening to the group's discussion appeared beneficial to them. It also appeared that not only has the classroom organization changed to enable group work, but more opportunities were now given to students to generate and to discuss their ideas.

It is apparent from the teachers' responses to interviews and class observations that their knowledge of teaching strategies had broadened. They mentioned the use of a wide variety of teaching strategies. Their knowledge of discussion as a teaching strategy was clear from their statements. Cindy said that the students did most of the talking, while Bert said that he learned from the students' discussions. The way they used games and puzzles could also be argued to show how their knowledge of problem solving, practice and practical work had widened. Normally, the teachers would use a game or a puzzle to introduce a concept and the students would practice skills with the use of manipulatives.

Mathematical investigations, which was one of the topics in their workshops, was agreed upon to be tried in class, especially in the top sections. However, not a single teacher tried it. Therefore, comments on their knowledge about this strategy could not be made.

In summary, it appeared that teachers' pedagogical knowledge, particularly on the use of teaching strategies, had broadened. They now talked and used different teaching strategies such as group discussion and practical work in class.

Changes in practices

This section describes the changes to teaching practices and practices associated with teachers' professional development.

Teaching practices

The habitual action of the teacher such as their use of particular teaching strategies and classroom management techniques will be considered as their teaching practices.

The existing teaching practices

Observations before the action research revealed some of the existing teaching practices of the participating teachers. It was routine for classes to start with a prayer followed by greetings. The teacher would then call students to show answers to the homework on the board. After this a presentation of the lesson followed, usually consisting of teacher exposition and questioning for facts and recall. Students would then do practice exercises individually in their seats. Afterwards, some of them would be asked to show their answers on the board. Then a student assessment, which usually consisted of five items, was given. What follows is a more detailed description of the teaching practices based on the teaching strategies found in the Cockcroft report (Department of Education and Science, 1982) and on classroom management strategies.

As observed, exposition for them would mean that the teacher would be the one to talk in front of the class most of the time, sometimes with the use of chalk and blackboard such as shown in Figure 3.

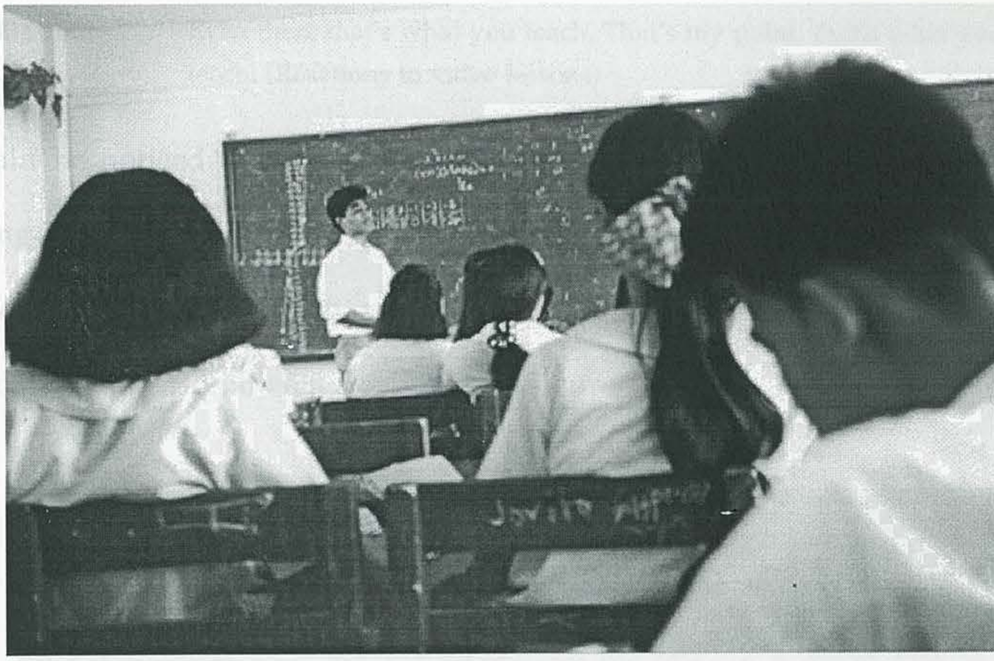


Figure 3: A teacher explaining the steps of graphing functions—an example of using exposition as a teaching strategy.

In one of Art's lessons, he used exposition as a teaching strategy. Below is the reaction of Delia, the school head.

Art: One thing that I did so that the students will be involved, I let them give the numbers.

Delia: Yes, but in the solution, would they still be involved? But in fact it was just a presentation, supposedly in the presentation, I'm not—it could be sometimes it's good that there's participation from students, but then what I observed, let's say you asked them: Give me a radical, √3, √2, the same and similar radicals for example. What I mean, Oh—how will you multiply this? What do you think? Here, guessing is established if we do this... For example it's you who is presenting a lesson on multiplication of radicals. And then you solicit examples from students. Okay, give me examples of similar radicals... And square of it... What I mean is this. You solicit so that it would start from the students, they have the participation. Okay, give me two radicals which are similar. So a student will give √2 and √3. How do we multiply these? Are you expecting that they will answer these correctly or they will just guess it? You would really expect that they will just guess it.

Art: No, only the easy ones are given as examples.

Delia:	Even then, that's what you teach. That's my point, that's what you teach. (Reactions to video lessons)

It could be noticed here the school head's disappointment over students making uneducated guesses. In the researcher's observations, as well as this kind of student participation, students were also asked to write on the board the answers to assignments as shown in Figure 4.

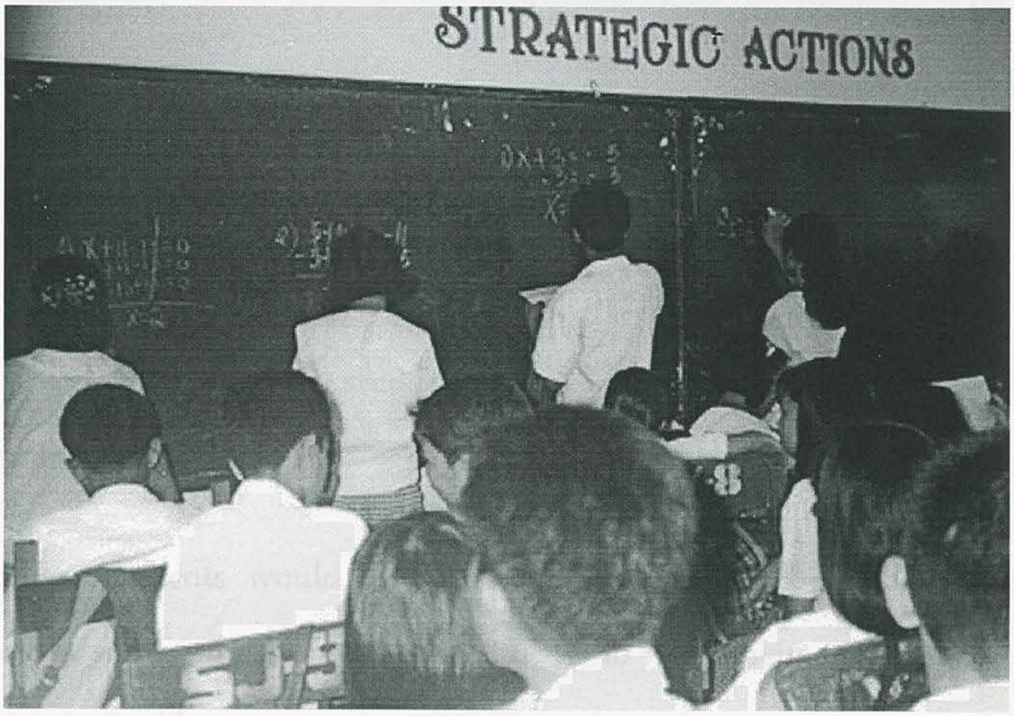


Figure 4: Students' participation is copying answers to the exercises on the board.

One teacher would also request one of his students to copy on the board a portion from the book while the rest of the students would copy what was written on the board in their notebooks. Afterwards, the teacher would explain these notes as captured in Figure 5.

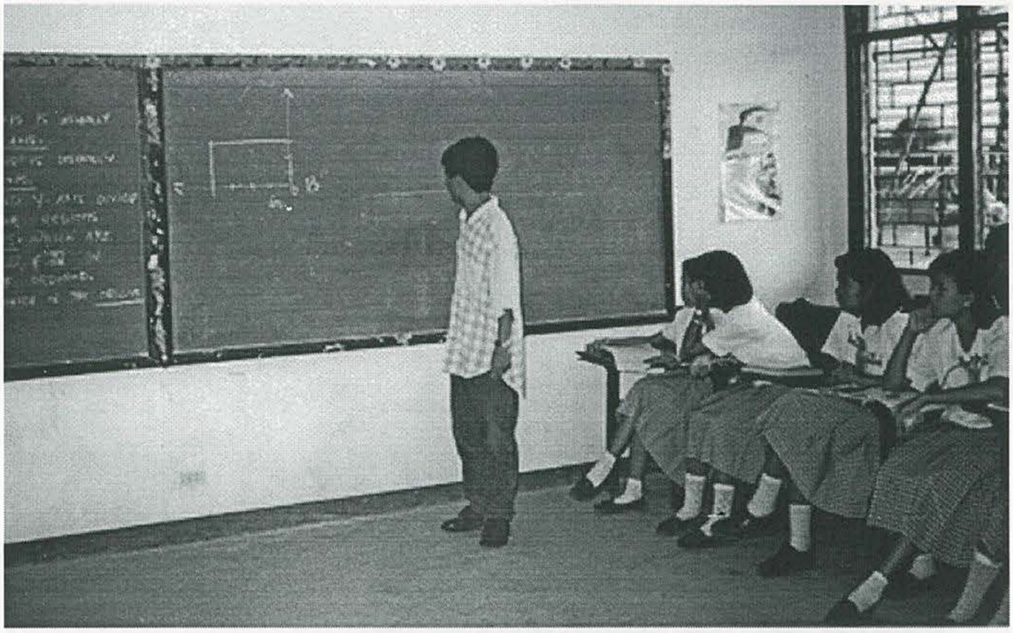


Figure 5: The left side portion of the board was used to write notes and the remaining part to give illustrations to explain these notes.

It was observed here that the students' role would be to listen to the teacher's explanation.

Sometimes, students would also do some practice work in their seats. Afterwards, some of them may be called upon to write their answers on the board in similar manner as shown previously in Figure 4. In one of the researcher's observations, during the practice activity, the students would sometimes go to the teacher to show their answers and the teacher was seen moving around to monitor their work (Figure 6).

Figure 6: Students doing practice exercises individually and the teacher monitoring their work.

Usually, practice exercises were done by students individually. The teacher would monitor the work of as many student as possible for a certain period of time.

Discussion between the teacher and the students was observed to be used as a strategy by one of the teachers to develop some of the ideas. As an example, this teacher would show on the board how the radical expression, $\sqrt{27x^3}$, was simplified and then told students to observe every step to arrive at the answer. Then, she asked these series of questions:

- How is it done?
- Why not combine $9x$ and $3x^2$ instead of $9x^2$ and $3x$?
- What do 9 and x^2 have in common? Why should these be paired?

Students would usually answer in either Filipino or English and the reactions of other students were sought about the answers. Then follow-up questions were posed.

Observations before this group undertook the action research showed that the teachers commonly used manila paper as a visual aid. Usually, it was used as a substitute for the blackboard by writing directions for students. Below is an example of one teacher's writings on manila paper.

$$\sqrt{27x^3} = \sqrt{9.3.x^2.x}$$
$$= \sqrt{9x^2.3x}$$
$$= \sqrt{9x^2} . \sqrt{3x}$$
$$= 3x \sqrt{3x}$$

Another example would be to write test items or assignments on the manila paper. It was observed that this type of visual aid was very helpful for their purposes because it saved time in writing on the board, was reusable for the next class and quite affordable. So, it was not surprising that on the top part of the chalkboard, a clothes line and clothes clips could be seen to pin these visual aids. A graphing board, made of illustration board, was also observed being used by a teacher in showing students how to plot points.

To sum it up, the teachers' teaching practices could be described as teacher-centered classroom practices. Teachers did most of the talking and the students participation would be mostly in answering closed-type questions or showing solutions to assignments or exercises on the board.

Changes made to the teaching practices

The major change that was observed in the teaching practices of the teachers was their use of different teaching strategies which resulted in the use of different resources. In order to give a more detailed description, the discussion here will be divided into two parts, first on the use of different teaching strategies, then on the use of resources.

- *The use of different teaching strategies*

It was observed that exposition as a teaching strategy was used during the action research. However, this had lessened so that not the whole presentation used exposition.

Discussion among students was used each time there was a group activity. Students would discuss answers to activities or to questions posed by the teacher. For example, in one of Cindy's classes, group discussion was observed. However, during the reporting, not many observations were made by the students which would lead to the mathematical description of the concept under discussion, in this case, similarity. Thus, when they were asked to give examples of similar objects that could be seen in the classroom, most of them just gave examples of objects which were of the same size and shape.

The practice and consolidation strategy was still observed in the teaching, this time with a variation from the usual chalk and board or manila paper. Games, contests, or competitions were used which were mostly enjoyed by the students. Often, teachers used different materials such as paper cutouts. cards, and calculators. An outdoor activity, as a practice on factoring expressions, was also observed. Figure 7 is a picture of students doing an outdoor activity.

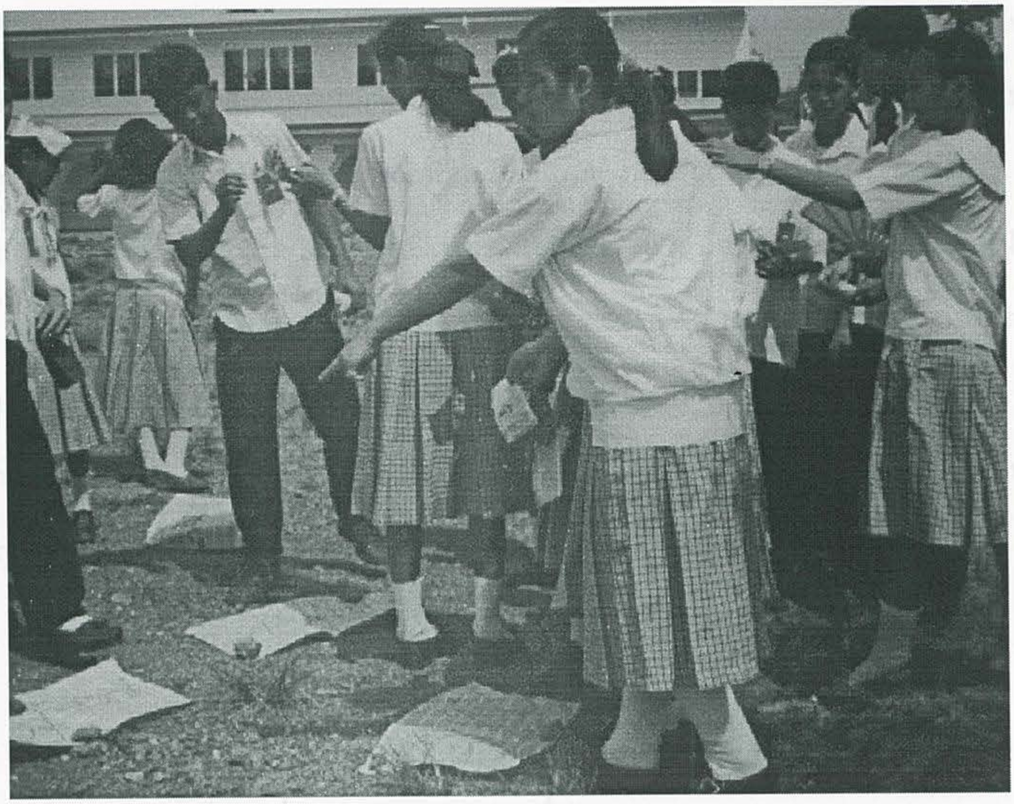


Figure 7: Students doing an outdoor activity.

The active involvement of students in this activity was demonstrated. It appeared that students liked this kind of mathematics activity.

Some of the activities used in class were observed to be aimed at teaching through problem solving. One example of this was developing the concept of factoring by completing the squares. The teacher's description of this strategy was as follows:

> The students were grouped into threes and were given one square and one rectangle. They were required to get the area of the square and the rectangle, then the sum of the [area of the] two figures. After getting the sum they were required to fold the rectangle into two and cut them, then were told to make a big square out of the

rectangle that was cut and the square. The last thing they did was recording the area of the big square. (Art, classroom diary)

This "big square" the teacher was referring to was the square formed when the three pieces (the small square and the two pieces that resulted in cutting the rectangular paper) were assembled into a hexagon. As an example, a student received a square sheet of paper with side x units and a rectangular sheet of paper with dimensions of x units and 6 units. Students cut this rectangular sheet of paper into two parts such that each part have dimensions of x units and 3 units. These three pieces were assembled and the expected result of the "big square" would look like Figure 8.

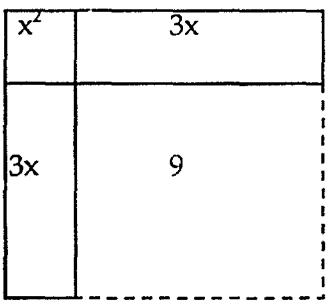


Figure 8: The geometric representation of factoring by completing the square.

It was observed that the students were able to form the shape as required, but seemed to have difficulty in connecting it to the topic of factoring.

- ***The use of resources***

Since the group agreed to focus on the use of practical work as a teaching strategy, it was seen that they did a lot of activities using materials. These materials were mostly teacher-made whereas others were student-made which the teacher set as projects. Commercial materials such as calculators were also used in some activities. The teacher's choice of resources mostly depended on the availability and suitability of such in a particular activity. For the purpose of describing in more detail the teachers' teaching practices when using resources, these are grouped in two categories: educational technology and visual aids.

Educational technology here refers to commercially available electronics or electrical equipment used by teachers or students to teach a particular topic. This could be a simple or scientific calculator, tape recorder, video recorder and the like. Visual aids refer to non-electronic or non-electrical devices. These could be materials used by the teacher (other than the chalk and board) to develop certain topics, as well as concrete objects for students to manipulate. These visual aids may be commercially available, teacher-made or student-made. The use of both educational technology and visual aids are discussed below.

Educational technology. Two teachers attempted to use educational technology in their teaching of mathematics during the action research study. The first teacher had, at one time, used a cassette recorder in giving the rules of the contest and the questions about exponential and logarithmic functions. This was an alternative to the usual seatwork which students do, using paper and pen to practice skills. Based on this teacher's diary, his assessment of the activity was this:

> The result or output is good since all of them [the students] were very eager in solving the given problems. They really followed the rules of the contest. The activity focused on how they listen to the problems, analyzing the problems and group

> cooperation. There's only one slight problem on the last portion of the contest, but not included in the contest. (Bert, Class diary)

It was indeed observed that students seemed to be interested in this method of practising their skills. Most of them actively participated in solving the problems for their group. After the contest, they even asked for solutions to difficult items. Also, this same teacher, on one occasion had his students bring one scientific calculator for each group of eight students. They used it in an activity to decode a message by solving questions on logarithms. The students showed eagerness to participate for they wanted their group to be the first to decode the message. However, it took them a long time to complete the activity. This could be due to the inadequate number of calculators and the length of the message. In this last case, because the message was too long, they have to solve too many items. It was remarked that to get every student in the group to be involved, more planning was needed. The involvement of every student in the group needed more planning. In the teacher's diary, these comments were made:

> Much better maybe if more than one calculator in each group could be used. Give practice exercise in using calculator but this time, maybe each student should have their own (if they have?) (Bert, Class diary)

The second teacher, had at one time assigned his students to bring calculators to class and a few of them were able to do so. They used it for guessing-game activity concerning equations of lines. It was observed that the students were amazed at how the game worked. They showed interest in what they were doing. One of the students even volunteered to give suggestions. However, after a few minutes, the teacher gave them the answers. Although they were allowed to use calculators, the students were not given the chance to try out their findings by considering other numbers as x-values. It appeared that combining different strategies such as using calculators and group discussion was a difficult task and the teacher was still tempted to give the answers right away.

Visual aids. During the action research, the use of manila paper was observed and was used as described in the preceding section. However, this time it was used by students to write the results of their group activity and then posted on the board for discussion, as shown in Figure 9.

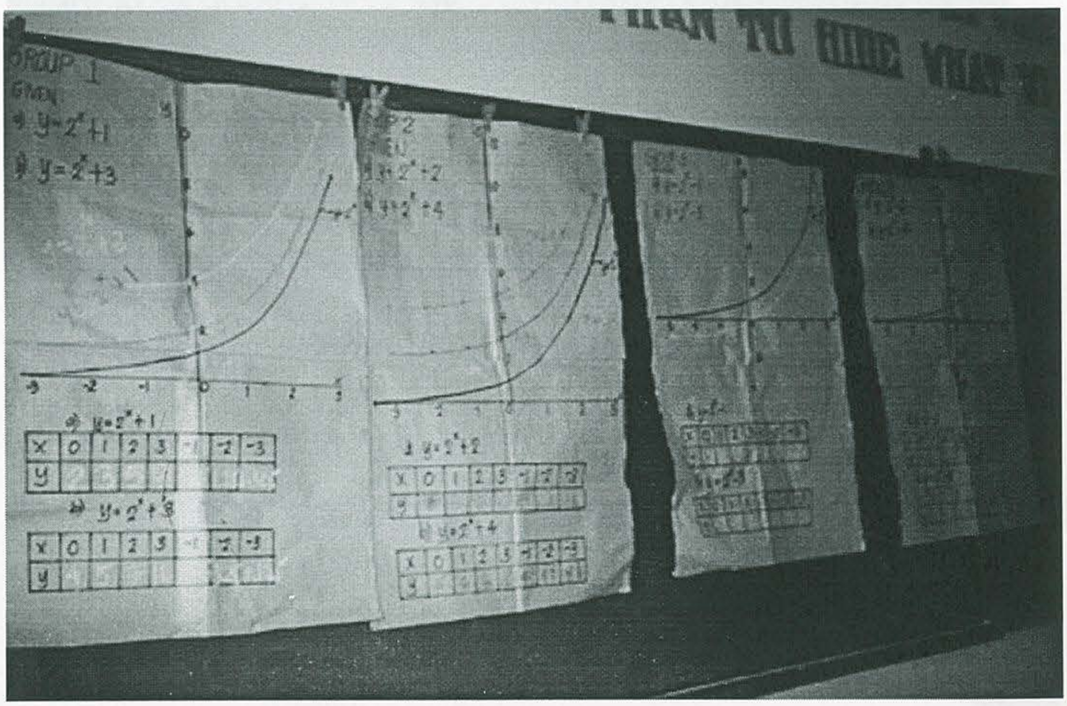


Figure 9: Results of students' group activity were written on a manila paper.

Other visual aids were used. Examples of these were geoboards, magazines or newspaper cutouts and number-line models. These aids were used in opening activities, developing a concept or practising skills.

It was observed that each of the participating teachers used different visual aids possibly because they were teaching different year levels of students. The first year teacher used different materials depending on her purpose. Sometimes she would use the materials for teacher demonstration especially if she had just one set like the pocket chart. In some cases, she would have quite a number of materials like the circular geoboards and tangrams for students to use. However, these were not enough for everyone so students would either find a way to see how the activity was done or would just not bother to participate, as shown in Figure 10.

Figure 10: Some students finding ways to be involved on the tangram activity, while the rest just stayed in their seats.

In the later part of the action research, a system was established wherein every student had access to materials. Materials such as number lines made of cardboard, illustration board or wood and bingo cards for integers were given as assignments to make, and as a result almost all students brought them to class.

The second year teacher used graphing paper in most of his activities. Towards the end of the action research, the use of triangles made of illustration boards were observed. For examples, students used these triangles in one of the activity to form one big triangle.

The two teachers teaching in third year would consult with each other about the materials that they could share. At times, one of them would just borrow the visual aids from the other, for example, the algebra tiles and grid board (made from illustration board covered with plastic). Students were asked to make these visual aids as a group project, and in some cases, it ended up with insufficient number of visual aids for the number of students. Readily available materials such as coins for the quadratic functions activity, paper cutouts for the similarity activity and paper strips for completing the squares activity were also used in developing concepts (see Figure 11).

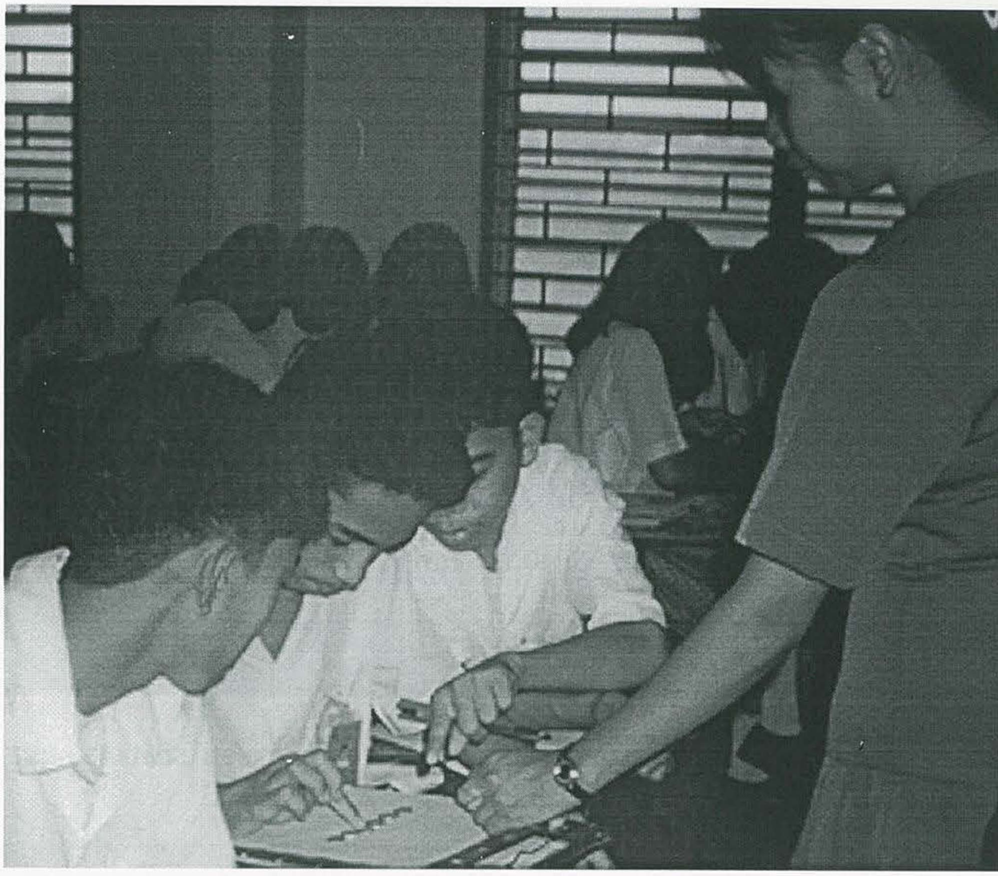


Figure 11: The teacher monitoring students' work on the use of coins and board for the quadratic function activity.

In the case of the fourth year teacher, he did some activities that required him to make use of materials, either by making them himself or assigning the task to his students. He made some grids on the manila paper that were distributed to every group for them to show the result of their graphs. Sometimes he would make use of newspapers and magazines for students to write their answers to some of the activities (illustrated in Figure 12).

Figure 12: Students doing group activity using scrap paper.

Big circular geoboards and gameboards which were made by the students were also used during group problem solving.

It was apparent from these observations that the five teachers had changed their practices in the teaching of mathematics. They used different teaching strategies and resources in different ways.

Professional development practices

While this study was in progress, the group of five teachers, sometimes joined by the rest of the teachers in the department, tried out several professional development activities. A comparison of the professional development activities they attended in the past and the professional development activities they were involved in during this study will be discussed.

The usual professional development practices

It was detailed in the literature review that the way teachers grow professionally can take many forms. In the case of this group of teachers, the interview data indicated that they were new to teaching and the only professional development activity they had been involved in was a one-week inservice course in which only three of them had attended. However, one of these three had attended a professional development activity in an area other than mathematics. Another had taken units in a graduate course.

Observed professional development activities during the study

During this study, several professional development activities were observed. These were:

- attending seminars or workshops
- observing peers and students
- discussing and sharing ideas with the group
- consulting peers, the head of school and the researcher
- involving other activities related to the project

Most of these are professional development activities which they participated in for the first time. Each of these is discussed in more detail.

- ***Seminars or workshops***

Attendance in seminars or workshops was considered by this group of teachers as helpful in their professional growth. While this study was being conducted, the group was able to attend three workshops on teaching mathematics. In these workshops they chose the topics and the design based on their perceived needs. They eagerly participated, cooperated willingly, became fully involved and enthusiastically tried all the activities. Figure 13 is an illustration of their active participation.

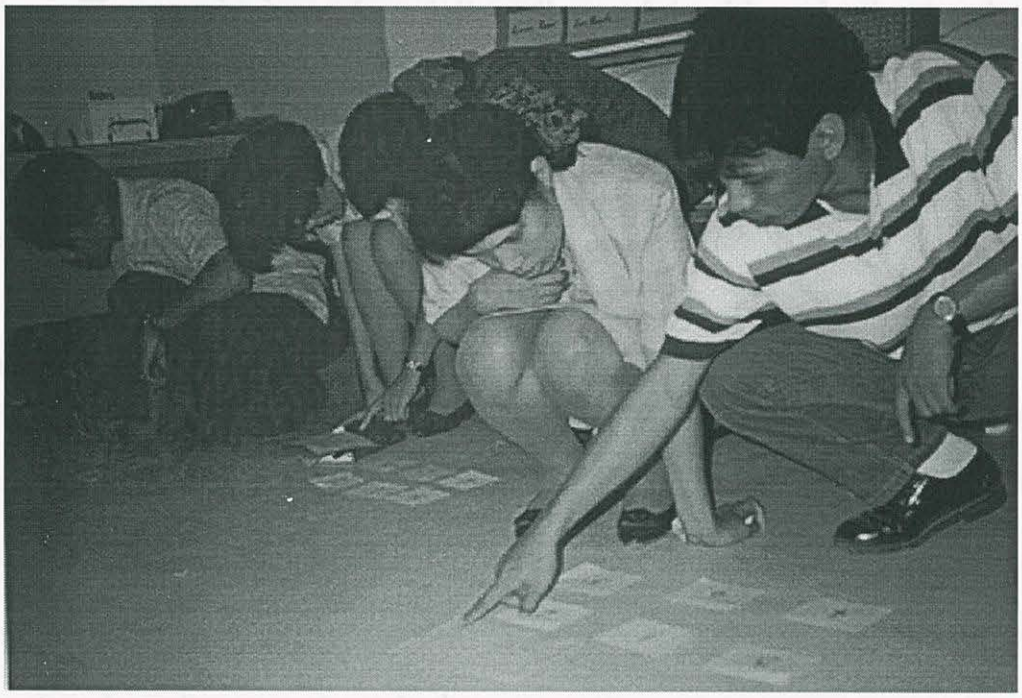


Figure 13: Teachers completely involved in a mathematics activity.

One of these workshops was attended by a representative from each school in the division and their respective department heads, the division assistant superintendent and the division mathematics supervisor. On this occasion, the five teachers participating in the study helped to facilitate the workshops, especially during group activities. The division mathematics supervisor stayed throughout and observed how teachers participated in the workshop. The feedback of this division supervisor regarding the workshop was relayed to the head of school.

> And you see the response. They are clamoring for the second one [according to this supervisor]. In your third cycle, they want to attend. I told Ms. Vicente [the supervisor], they could have a problem on money. (Delia, Cycle 2 meeting)

It was reflected here that teachers were very keen to attend another workshop. They could have found it really useful, although the head of school mentioned possible financial constraints. She was probably referring to teachers from other schools who would need some assistance to meet expenses, such as transportation costs.

- *Group sharing and discussion*

The teachers participating in the study would look for activities in books or other resource materials that they could use in their teaching. Sometimes they would find one that looked interesting but which was not suited to their topics. In such a case, they still would get it and share it with other teachers to whom it was more suited.

> You gave us many books? We divided them and at night time we read them. And we decided if it can be used for the lesson. Not so sure. Then I was able to give it to Ellen, no to Angie I think. That one on dividing a 100, 100, 110, 10, 10 ... She did it. I said at least this one could be useful to you. She said, oh, yes this can be. She got it. But then the others, none. Sometimes I couldn't give them; this can be, just like this. (Cindy, Cycle 1 meeting)

Cindy appeared happy to share mathematics activities she found in books and felt unfortunate that she could not always share with them.

Informal discussions at times also gave them ideas on what activity to use and how it could be presented in class. In one of the meetings, the discussion went like this:

Teresa: Ma'am, on January we'll be on integers.

Delia: There are many activities there, right?

Researcher: There are so many activities on integers, those soldiers, the walk-

Cindy: That's it ! I know. That one on boat and sharks. There's boat there and sharks here. (Cycle 2 meeting)

It was revealed here that some of them would ask for suggestions and that sometimes many suggestions would be given by anyone from the group. Figure 14 shows the usual arrangement during the group discussion.

Figure 14: Usual arrangement during group discussion

With the informal discussions, everyone seemed comfortable sharing their experiences and ideas.

- *Consultations*

Consulting or seeking help from another member of the group was frequently observed during this study. Most often, the researcher was consulted about the suitability of their planned activities and how these activities could be presented in class. Sometimes they would ask for tutorial sessions. They found the tutorial sessions useful especially when it was their first time teaching the subject. These sessions were also useful when they may have been teaching the subject before but had skipped certain topics because they believed they were not confident enough to teach these topics. There was also a time when one of them welcomed the help offered by the department head as to how an activity could be presented in class.

Cindy:	It happened—that one on completing the squares. He wasn't there during our inservice. So, I explained to him what to do. But he said: Cindy, it didn't work in Lanzones.
Researcher:	Because he didn't see it?
Cindy:	I said, wait a minute. What's your next class? I will show you how we did it.
Researcher:	That's it!
Cindy:	Then, as if—he said when he entered in Kaimito: Here, I *borrowed* Ms. Andres so that we'll have an easier discussion. So, I started. Ah, you did it one at a time. It appeared that what he did, he presented the table then filled it up. Since, maybe the students are not used to that, they hesitated to do it. What I did in Kaimito because they're in the lower section, this would be the first, this is your figure. He gave it. Then the area, you write it here. If you add these, what will you do? Ma'am, we'll put a dash. So he put it here. Then you'll get half of this. I really considered each cell on the table. Ah, so that's it. Okay, on the next class that will be done, he said. (Cycle 2 meeting)

Cindy's demonstration teaching gave a 'concrete' illustration to the other teacher how a certain activity could be used in class. On one occasion, the researcher was invited by one of the teachers to handle his next class and to present an activity taken from the PASMEP resource book. This was an activity on graphing quadratic functions using counters which the teacher was not familiar. He tried this activity twice in his previous classes but was not satisfied with the results. He believed that the contribution of the researcher would be a valuable input.

- *Observations*

It was clear that the group also learned through class observations. The demonstration lessons conducted by some members of the group were attended by most mathematics teachers in the department (Figure 15).

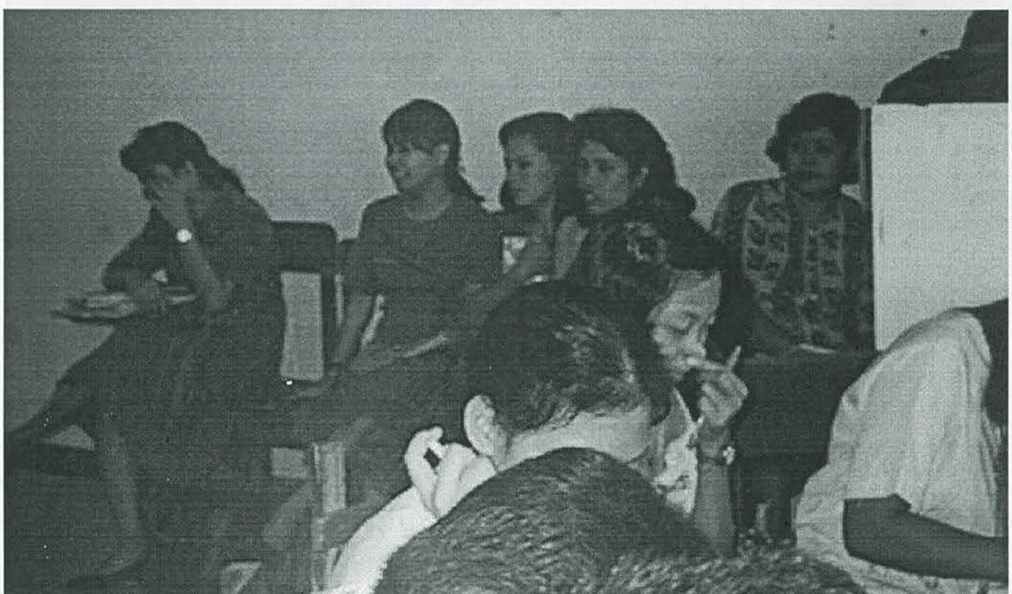


Figure 15: The head of school and mathematics teachers observing a demonstration lesson by one of the participating teachers.

This demonstration teaching and the critique that followed gave them ideas on the teaching strategies that could be used in class. Lessons in which videos had been taken were also viewed by the group and the observations and comments were similar to those from the demonstration lesson. There was also a time when one observed the class of another so as to give him ideas as to how the activity might be used in his class. Figure 16 shows a snapshot of this participation.

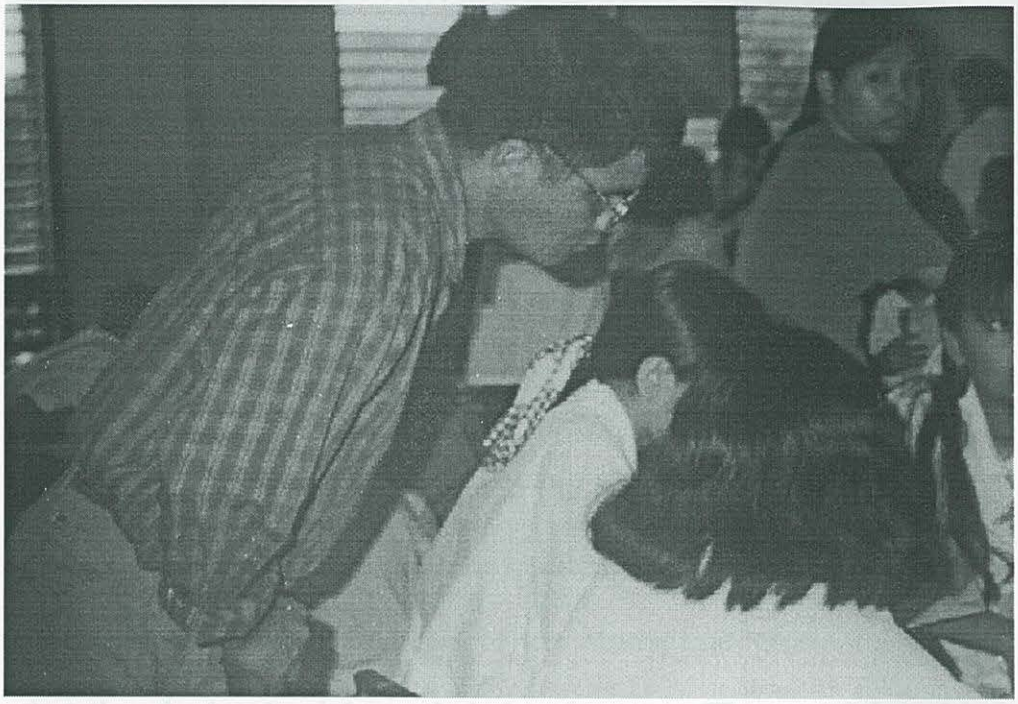


Figure 16: One teacher observed the class of another to see how the activity is used in class.

• *Other activities related to the project*

This study required the participants to do some extra work such as preparation of activity sheets, writing diaries and attending seminars or workshops. Teresa, Alex, Art and Bert helped to facilitate the workshop attended by mathematics teachers from the nearby schools. Cindy presented sample lessons that would show how students could be encouraged to participate in problem solving, reasoning and communicating mathematics (refer to Figure 17).

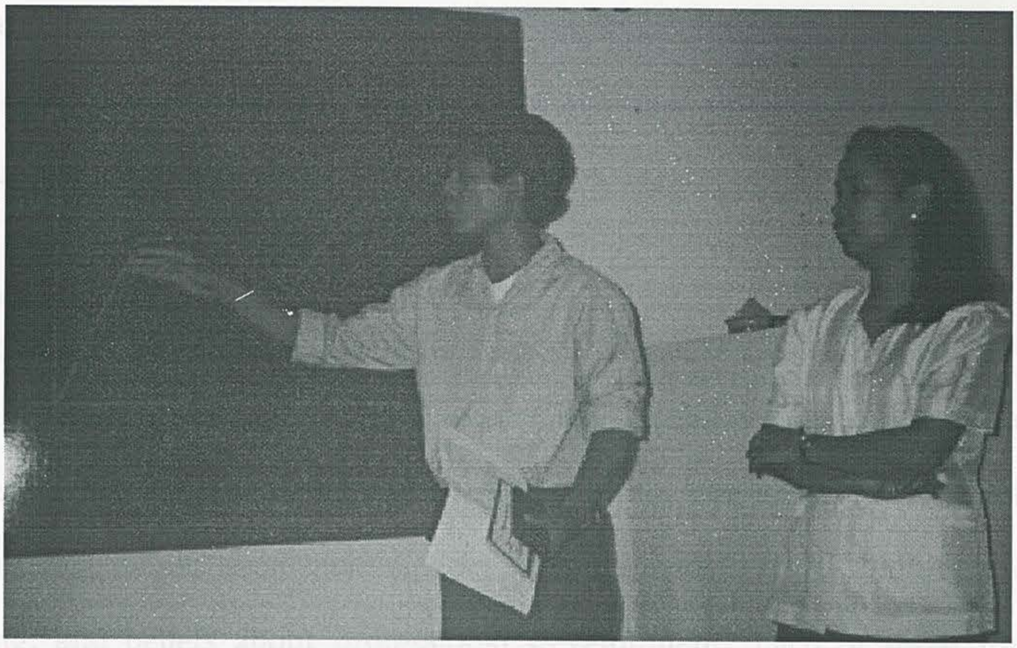


Figure 17: Cindy facilitating the workshop

These different experiences have affected the teachers' professional growth. There has been a change in the way they practice professional development and their attributions. Near the end of the study this group talked more about what they had gained from their involvement. They said that this led them to do more self-study and reflect on what they were doing and they also came to realize more about their professional development needs.

> Learning on what we did. Just like this. What I learned before, I realized, it was not enough. So with the group, they were able to help me. Honestly, this is my first time to teach math. I don't know some of it. I just learned it. (Teresa, Cycle 3 meeting)

Teresa was acknowledging the help of the group members for her professional growth.

It appeared that their involvement in the study gave them the opportunity to try a range of professional development activities that can help them in the teaching of mathematics.

Changes in beliefs

Through interviews and discussions, the beliefs of these participating teachers were examined. Those related to teaching and learning of mathematics were considered and categorized into four areas: beliefs about mathematics, beliefs about mathematics teaching, beliefs about mathematics learning, and beliefs about professional development. Each of these four categories is discussed below.

Beliefs about mathematics

The beliefs of this group of teachers about mathematics before the start of the study and while it was ongoing were considered.

Initial beliefs about mathematics

Individual and group interviews with the five teachers at the start of the study revealed that their beliefs about mathematics were mostly concerned with its nature, its applications and the students' perceptions of the subject.

During the group interview, both Cindy and Art agreed that the nature of mathematics was "maybe on analysis". In the individual interview that followed, Cindy seemed quite definite on this matter.

> The first and foremost requirement in mathematics is that you have to learn how to analyze. This analysis, whether its a personal problem, or a problem at home, you really need this skill. You can apply this skill. You learn to consider the pros and cons, the positive and the negative and so you can weigh it. This is indeed the skill that should be developed among our students. (Cindy, III-Beliefs and Practices)

Cindy appeared to emphasize the importance of students developing skill in analysis. This she felt could help them in their decision making in real life.

Two other teachers had a different view about the nature of mathematics. For them mathematics was more about getting an answer or solution to a problem.

> It's all about computations. (Alex, III-Beliefs and Practices)

> Mathematics-it's a perfect science. You cannot make a guess, your answer should be it, say if it's one, it's really one and cannot be negative one. (Bert, III-Beliefs and Practices)

All of the teachers believed that mathematics was important to learn for two reasons: its usefulness in everyday life situations and its applications to other subject areas.

Another belief which this group held in common was that students found mathematics difficult to learn. In an initial individual interview, each of these teachers was asked how they compared mathematics with other subject areas and one of them said that "mathematics is difficult for the majority of them". Similar statements came out during the group interview.

> Teresa: Like my students, they like math but they find it difficult.
>
> Cindy: My student, too... He would go to the blackboard to solve, but he has the difficulty of doing it. (IGI-Beliefs and Practices)

It was interesting to note that they believed their students liked mathematics but found it difficult. This may have meant that their students were willing to participate , but required assistance from the teacher. It was apparent that many of the teachers' beliefs about mathematics were based on classroom observations of their students.

Later beliefs about mathematics

Data based on the individual and group interviews and discussions with the five teachers, while the study was ongoing, revealed that there were some changes to their beliefs especially in relation to the nature of mathematics and how students viewed it.

Alex, who made a short statement on the nature of mathematics before, now has more to say:

> Before it was computation? Before it was computation, remember? Computation I said the last time? It's really computation if it's math. Computation, but now it's also on analysis. Math is on analysis, you have to analyze it. Not only computation. By using, what we call this, materials, we can demonstrate mathematics. (FII-Beliefs and Practices)

He appears to have broadened his previous statement that it was "all computation". Now, he believes that mathematics could include analysis and the use of materials. In the case of Cindy, she still viewed mathematics as before, that is focusing on analysis, and elaborated on it this time.

> Math! Because so far, my view didn't change that it really helps if you have understanding, especially skills in math, the more on higher skills. When it comes to analysis, you could really apply it even to real life. Now, it's more, how would I say this? I have a broader concept of mathematics. Not only—because the start to us before was problem, you solve it, given today, submit tomorrow, it was something like that to us. Often, 1 to 10 problems, then assignment, take home project. But now, there are times, you could give not necessarily all problems, something like that. (Cindy, FII-Beliefs and Practices)

Again, it appears that Cindy has broadened her view of mathematics to include understanding as well as the higher order skill of analysis. In the case of Art, his beliefs about mathematics did not change a great deal.

> It is the study of skills, computation, analysis and practical usage. Those numbers, including numbers, analysis, ah, practical use. What else? Ah, computation, that's mathematics. (Art, FII-Beliefs and Practices)

A comparison of Bert's beliefs about mathematics indicated that he made almost the same statement as before.

> For me, yes, it's really a perfect science. You should really not make mistakes, I mean, your answer should not really be close, but should be exact, something like that. Say, if your answer is 20, so 20. It can't be 19, nor 8, so really exact, so it's really perfect. (Bert, FII-Beliefs and Practices)

Bert showed agreement to the often heard statement that 'mathematics is an exact science'. Here, the focus is on the answer to the problem, rather than on the process of getting the answer to the problem.

Considering their statements about their beliefs on the importance of mathematics towards the end of the study, it could be seen that they still viewed mathematics as important and that the reasons were still the same. Cindy elaborated on this.

> It's one of the things that you use everyday. The skills that you acquired, you use it everyday even in real life. Those basic, the four fundamentals, as usual. Even on analyzing something you want to do, how would you approach it, which side are you going to do, where would you start? Skills like that are needed to be developed among students, so that even a simple problem at home, they would know how to approach it. At home or in the office. Now, if their needed skills are developed, they could apply it in real life. But then, we still have a problem when it comes to linkage. That's the problem. They didn't realize that they could apply it to the

> problem that they're doing at home. When they conceptualize the problem, it can't readily be solved as that. Not there at once , but which one to do first. They have to analyze the first step, the basic steps to do before they could proceed. Which ones first—the steps of the process. (Cindy, FII-Beliefs and Practices)

Cindy here indicated the importance of developing process skills among students which would be helpful in their everyday life. However, she had a concern about the transfer between mathematics taught in school and mathematics used in everyday life.

Towards the end of the study, it was apparent that the teachers still held similar beliefs about mathematics identified at the beginning of the study. However, it was also noticeable that these teachers had broadened their view about mathematics. This could be attributed to the changes they had made in their teaching of mathematics, for example, through the use of activities, and also as a result of their discussions and sharing of ideas with the other members of the group.

Beliefs about mathematics teaching

The participants' beliefs about the teaching of mathematics at the start and before the study ended were documented from interviews, discussions and diaries. The teachers shared their beliefs about teaching mathematics, particularly in the strategies of presenting a lesson, roles and responsibilities of a mathematics teacher and attitudes that mathematics teachers should possess. These beliefs are discussed in this section.

Initial beliefs about mathematics teaching

At the start of this study, a range of beliefs about mathematics teaching were ascertained. One of these related to the roles and responsibilities of a teacher in teaching mathematics.

> In teaching mathematics, the teacher must exert more effort because students now would rather prefer going out, so we should be lenient and very professional with our teaching... I need to study more when it comes to mathematics, but I'm trying my best to find a way to improve my teaching. Sometimes I ask the help of my co-teachers. At times the students suffer with our mistakes. (Art, III-Beliefs and Practices)

His statement could reflect the belief that the teacher has a responsibility to make an effort to motivate students to attend classes. This would require the teacher's on-going commitment in professional development activities such as discussing and seeking help from peers.

Some of the teachers believed that in teaching mathematics, the way of presenting a lesson should vary and this should depend on the academic standing of the group. The language used by the teacher should also be considered.

> Cindy: Usually your approach with the higher section would be different with the lower section. Because the one that you used in the higher section couldn't be absorbed by the lower section [students].
>
> Teresa: So you really need to use Tagalog in the lower section. (IGI-Teaching and Changes)

These teachers believed that the type of lesson should vary in terms of presentation and language so as to suit the group of students. However, the connection between beliefs and practices was not apparent as little variation was noticed by the researcher when these teachers were observed in their classes.

The use of visual aids was also believed by some of the teachers to be useful in presenting a lesson.

Researcher:	Ah, so then, why do you want to use visual aids?
Teresa:	Because it can easily attract students. Can easily arrive at ideas, especially if the material you used is something different.
Cindy:	They're more interested in it.
Teresa:	They're interested in it.
Cindy:	As long as it's something manipulative. (Planning meeting)

They seemed to believe that a variety of visual aids such as manipulatives would attract students' attention and assist their learning. However, the use of visual aids was not observed in the teachers' classes except for brown paper with some notes on it.

The teachers believed that some strategies, like group work and the use of activities were not easily managed in their situations. They discussed this issue in one of the meetings.

Delia:	But then in group work, it takes time, because they have a defect, they have a problem in comprehension.
Art:	Then the students will be noisy in group work.
Delia:	So it will take longer if—
Cindy:	When we had this meeting about making it forty minutes, I said-
Delia:	So what should be really done? Would you still continue with the use of activities. Because you said you're considering the time.

Teresa:	Time really for activities.
Art:	If activities, it will take longer for students. We have just 40 minutes. It could be that its only the activity that can be done.
Teresa:	Yes, it would really be just the activity. (Planning meeting)

Here, the initial hesitation of teachers to use group work and activities was apparent for they felt that this would take time considering the percieved characteristics of students they had to teach. Their students were neither used to group work nor to the use of activities.

When they were asked about the role of mathematics teachers, their answers were related to how they viewed mathematics teaching.

Art:	It's like, really an encourager.
Researcher:	Encourager?
Art:	You just have to tolerate them.
Researcher:	Tolerate them, why?
Art:	Because the children when they felt embarrassed, although it's his favorite [subject], this would vanished.
Researcher:	Do you think we are here to give [to children] what we really know? (Nods from them) Giver of knowledge?
Cindy:	Transmitter
Alex:	Supplier.
Researcher:	Transmitter? Supplier, Alex?
Alex:	For those who are lazy.
Cindy:	And those with no initiative. That will be the tendency, and that's the system not only in one subject, because that's the need. There should really be a word that should be remembered or a situation that is presented that should really be understood. But if you leave these to them to understand and analyze, they won't. Those with initiative that would really come from them, you can count these children on your fingers.

Researcher:	So if the teacher is the *giver* of knowledge, is this the case? (A nod from them) What do you think would be the role of students?
Cindy:	Not all of them are very good, that's our problem.
Teresa:	Receiver. (IGI-Beliefs and Practices)

It is interesting to note here that they believed that the teacher should be responsible for encouraging students' understanding by being the 'transmitter' or 'supplier' of knowledge and where the students are just the 'receivers'. Indeed, the teachers found mathematics teaching a challenging task.

> Mathematics teaching is challenging, how to facilitate the lesson and I would say that there is mathematics learning in the honor section. (Bert, III-Beliefs and Practices)

Another belief that seemed worth noting was the teachers' openness to change. Art made the following statement when asked if they wanted to make changes to their teaching of mathematics.

> Of course we need changes if you're teaching. Not that you have to stick to your usual ways. (Art, IGI-Teaching and Changes)

It is evident that Art believed that teachers should explore other ways of teaching. He made a similar statement when he was interviewed alone.

> Teaching is learning. Maybe your strategies for today will not be applicable tomorrow, so it's a continuous learning. (Art, III-Teaching and Changes)

These statements indicate that teachers were aware that there is a need to change and that they were willing to explore the possibility of making changes to their teaching.

These beliefs about mathematics teaching were focused on how a lesson should be presented and the roles, responsibilities and attitudes of a mathematics teacher. Some of these teachers believed that a mathematics lesson should be presented in such a way as to attract students' attention. This is why more emphasis is put on using visual aids. They also believed that the teacher should be the 'supplier' of knowledge and the students the 'receivers' of knowledge. This belief was often reflected in their teaching practices. Another belief that emerged was the belief that professional development should occur alongside classroom teaching.

Later beliefs about mathematics teaching

Results from discussions during meetings, interviews and diary entries gave an indication as to whether or not the teachers' views about mathematics teaching has changed towards the end of the study. In fact, the teachers still talked about their beliefs in terms of teaching strategies and the teacher's role, responsibilities and attitudes to teaching mathematics. However, as the study progressed, they provided further elaboration.

In relation to presenting a lesson, teachers believed that there could be a range of different approaches.

> For me, it's really okay to include games in the lesson and at the same time there's learning in it. Impatience will be overcome so with getting bored or let's say *hate* in math subject will be minimized if there are games like this... Really various activities and strategies are needed like food that you have to do it. It's exciting and okay if it varies, right? But, really effort is needed in the preparation. I'm not complaining, ha! (Bert, Diary)

Bert seemed to be happy with the use of activities even though activities required more preparation. He seemed to be convinced that the results were worth it. He made a similar statement in an interview. He said that it would be good if activities could be used in some lessons, but added that there should not always be activities because the preparation would be tiring for him.

Some of these teachers also mentioned their beliefs about the attitudes teachers should have in teaching mathematics. One of these beliefs include the acceptance that there is learning in teaching and that in some cases teachers can learn from students.

> For example, one time you were observing, remember? I made a mistake. It's said that it's good to make a mistake and a student would see it. At least you have someone to turn to, somebody who would observe you and say something's wrong. So this student approached me. Sir, as if I'm confused with our lesson now. After that I was able to recall it, it was corrected. Ah, yes, right! See. There I explained that I made a mistake, so I corrected it. Sir, you taught us wrong yesterday So now I made changes and apologized. (Bert, FGI-Beliefs and Practices)

Bert showed openness to ideas by accepting students' suggestions and comments and by apologizing when needed. In like manner, Teresa had this statement on the issue of students giving suggestions.

> We have this before that, *I'm sir* so you can't do that to me. It was like that before. But now you can also accept from a student. (Teresa, FGI-Beliefs and Practices)

It is apparent here that there was a change in the belief that a teacher should not be questioned by students because "I'm sir", someone who is in authority and the 'giver' of knowledge. This seemed to contradict their earlier view that students were just 'receivers' of knowledge. Now, they indicated an appreciation of students' suggestions. This could be seen as one of the major changes in the teachers' beliefs. In the Philippines secondary schools, allowing students to be critical of what has been discussed is seldom observed. Students are careful not to question teachers, for this may appear as a sign of disrespect for authority or for someone older than themselves.

Another attitude which they viewed as important was tolerance. They believed that at times a teacher should tolerate aspects of the students' behavior.

> Art: You just have to tolerate them.
>
> Researcher: Tolerate them, why?
>
> Art: Because the children when they felt embarrassed, although it's his favorite [subject], this would be gone. (IGI-Beliefs and Practices)

Showing tolerance towards students' behavior was perceived to encourage students to participate in class activities. With regards to taking the risk of trying out new ideas in class, two teachers had opposing views.

> At times if I know that it [activity] is difficult, I won't use it, anyway nothing will happen because they won't understand. So what I did, I just discussed it. But sometimes I want to try, but then I became negative. It might be that my teaching will fail, right? It's a mistake! Or I would think if it's related to my topic. Sometimes I'd like to do something but I didn't do it because my mind was confused. Also, sometimes I have something I'd like to teach, but it seemed I don't know. I would think, what if the students will question me about it? At times my students would ask me and I don't know, especially my students in Sampaguita, there are so many of them there that would ask you. (Teresa, FII-Beliefs and Practices)

Teresa seemed to have a belief that an activity which looked difficult should not be used in class because "nothing will happen" anyway. Although, she confessed that sometimes she wanted to try an activity in class, she hesitated because she lacked confidence, apprehensive that her students would question her about it. Cindy had an opposite view.

> For me, if it's something new and I know it works, I'm willing to try it. I'm like that. Even though, you'll say they'll make noise, if I know it'll work, why not? That's my attitude, why not, why wouldn't try? Yes, you would try it first, if it really wouldn't work, then find another. (Cindy, FII-Beliefs and Practices)

Cindy showed willingness to try activities in class and seemed not to mind if they failed or were not as successful as she had expected.

These five teachers also talked about their beliefs regarding the roles and responsibilities of a mathematics teacher. They all seemed to agree that the teacher should be both the 'giver' of knowledge and the 'taker' as well. A quite long discussion about this went on during the final group interview.

Bert:	A student could also give you knowledge, right?
Cindy:	Give and take.
Bert:	Yes, that can be, remember? Like that one...
Cindy:	It's now give and take. But our role as a teacher, that's the basic.
Researcher:	Yes?
Cindy:	Because, suppose to be it should really come from us. But this does not necessarily mean that we can't learn from the students. The teacher could also learn from the students as long as the students could learn from them.
Researcher:	So now, what do you think? How about you, Teresa? What do you think, what would now be the role of the teacher? Mathematics teacher? (Interruptions from other teachers) Come again, Teresa?
Teresa:	Facilitator.
Researcher:	Facilitator. What do you mean by facilitator?
Teresa:	You have to guide the students.

Researcher:	Through what?
Teresa:	On the... let's say, you have to give the students a problem, right? But on that problem, they will solve it, you would help them, for example, through your questions, giving some examples... We just give and take. Unlike before that it should all come from the teacher.
Researcher:	How about you, Alex? (Paused)
Alex:	It's about what? (Laughter from the group)
Researcher:	You, Alex, ha ? (then laughed)
Cindy:	Role of a math teacher.
Researcher:	What do you think would be the role of the math teacher now?
Alex:	Role of a math teacher? If you say math teacher, your role would really be to give—you process it so that they would know.
Researcher:	What do you mean by process?
Alex:	You need to know first how to solve the problem, then when you're done with it, it's up for the students to apply it, how would they solve another problem...
Bert:	So, if we're the facilitator, we'll make the lesson easier, not that we actually have to give it all, that's why we're facilitator so that, for example you'll have to give clues so that they can get the idea. It's not that you [the teacher] would always be the one to give, some would also be coming from them. Something like that. So, maybe art of questioning will again come in. (FGI-Beliefs and Practices)

It emerged from the discussion that they now believed that, in the classroom, there should be 'give and take' of knowledge between the teacher and the students. This appeared to widen their earlier view about the teacher as the 'giver' of knowledge. Now, they seemed to believe that the main role of the teacher in a mathematics class was that of a facilitator. Bert described this role in the transcript above. The teachers' beliefs about their responsibilities were also mentioned by Art.

> My belief is that students have already something in their heads, only it's the teacher's responsibility to properly motivate them and have it developed in them. Teachers have really a great responsibility. (Art, FII-Beliefs and Practices)

Art's statement on the teacher's responsibility focused on encouraging participation from students, while Teresa focused on teacher's preparation, specifically on the mathematics content.

> So for me, you couldn't teach math well if you won't study. Of course you'll teach so you'll have to study. It's always like that in mathematics teaching, you need to be always ready. You need to know more, because sometimes students would asked you [questions] not related to the topic, so if you don't know it, how would you answer that student? (Teresa, FII-Beliefs and Practices)

Both Art and Teresa held the view that teachers should be responsible enough to make the necessary preparations so that everything would be ready when they were in class.

In summary, the teachers based many of their views about teaching mathematics on observations, discussions and reflections about their students. A change in the way students worked in class seemed to result in change in beliefs. These teachers now believed that mathematics teaching should include different strategies or activities such as using games. Also, teachers seemed ready to open themselves to students' suggestions, for they started seeing mathematics teaching as a two-way process. Also, students could learn from their teachers as well as from their classmates, and teachers could learn from their students. In this way, the teachers believed that their role was now more of a facilitator in the classroom.

Beliefs about mathematics learning

The five teachers talked in group interviews about what they thought students should do in order to learn mathematics. These views are discussed below in two parts: before the action research and when the action research was almost complete.

Initial beliefs about mathematics learning

Before the group began the action research, interviews were conducted about what they thought students should do in order to learn mathematics. Teachers' answers were focused on two things: students' attitudes and teachers' responsibilities.

Some of the teachers believed that students should listen and be attentive to a teacher's discussion in order to learn. They should also try to solve more problems or exercises and do more practice. One of them added that students should persevere in order to learn mathematics.

> First and foremost, they should be persistent. If you give a problem and they find it difficult, they immediately give up—that's the tendency. At times, I could see that a student would like to try. At first they would hesitate for it might be wrong. I told them I won't eat them nor get mad at them if it's wrong. At least, sometimes I could encourage some of them to try, however, there are really students who would not try no matter what I'll do. (Cindy, III-Beliefs and Practices)

It is evident that Cindy encouraged her students to participate. Still, she showed frustration when those students would not try.

The teachers also thought that in order for students to learn mathematics, teachers should do their part. Teachers should teach simple concepts first and then move to complex ones in order to facilitate understanding on the part of the students. Visual aids should be used not only to attract students' attention but also as a teaching aid to support learning. These statements were related to their beliefs about mathematics teaching. Giving encouragement to students was also seen as important.

> I think, this is my belief on how to learn about these numbers. First encouragement—encouragement is really needed because students have individual differences in terms of their learning process. (Art, III-Beliefs and Practices)

This teacher was acknowledging the individual differences of students which may indicate that some of them were not motivated to learn, and needed encouragement. Another interesting comment made by one of the teachers was that there should be peer learning among students.

It appeared that for this group of teachers, mathematics learning was the responsibility of both teachers and students.

Later beliefs about mathematics learning

Group discussions, and interviews with these participating teachers near the end of this study in the school revealed that their beliefs about the learning of mathematics had broadened. They now considered what mathematics learning really meant to them, how mathematics was learned and what attitudes students should have in order to learn mathematics.

When these participating teachers were asked to say something about mathematics learning, these statements were typical:

> Math learning? Because it's like acquiring skills. It's what's this, how will I say this? Math learning is acquiring skills, developing your understanding about figures, something like in conception with geometry already. Before, even them, if it's geometry, it's about lines, all those conceptions [perception] that it's difficult to understand, that you need to have the perseverance. Now, that changes, not everything is that difficult as well as everything that you see in mathematics is that easy. As if this was broadened, increased, something like that. (Cindy, FII-Beliefs and Practices)

Cindy appears to have had a perception that mathematics learning was about acquiring skills and developing understanding of mathematics concepts.

Teachers considered how mathematics learning for students could be enhanced. They believed that mathematics could be learnt through activities, formula, problem solving in teams, asking questions and self study.

> There is [referring to learning in doing mathematics activities]. They learn to discuss, they would say, that's it, they seemed to discover through the activity. They would think that it was that easy, the way ma'am taught them. For example that one on fraction. I gave them a whole then they divided it into two, so they saw that that's one half. In the classroom, through discussion, cooperation and involvement of every student, they would learn from it. (Teresa, FII-Beliefs and Practices)

In the above quotes, Teresa described how the activity on fraction enabled students to learn the concept easier. This different way of introducing the concept to students was also mentioned by Alex.

> It used to be when we solve it, when we find an answer to the problem, it's by computation. But now it can be done through an activity. No need to use computation, you can solve it, you can get the equation by using the activity. (Alex, FGI-Beliefs and Practices)

Both Teresa and Alex mentioned how useful activities were for students' learning. Alex even reiterated this during the individual interview.

> Learning? Ah—they can easily understand because they saw it on the figures, in your examples, materials, they've seen it and they even got ideas from it. Before, math learning, when they entered, what's on the blackboard, that's it. They just listen, they didn't have participation. Unlike now, they even volunteered [to participate]. (Alex, FII-Beliefs and Practices)

Alex's statements seemed to reflect how most of them viewed mathematics learning. It appeared that the teachers' views of learning have extended to ways other than just listening passively. They seemed to have realized the importance of active participation in fostering effective learning.

There was also discussion on the attitudes of students that support mathematics learning. Compared to those mentioned before the action research began, teachers now added to their list of attitudes that students should possess. They believed now that students should be willing to be involved in classroom activities such as group work, class discussions and in the practice of skills. Below is an extract from a group interview on how people learn mathematics.

Cindy:	Willing to learn.
Researcher:	Willing to learn. What else?
Cindy:	He's willing to learn?
Researcher:	How? When they're willing, they would already learn? (Paused) Would they just listen?
Cindy:	When I say willingness—It's not just that you just sit down and listen, what you heard you learn it. No! When I say willing, you have to try whatever is asked of you to do, you have to try it.
Researcher:	Yes—what are they going to try?

Cindy:	Say, in activity, right? There is a need to manipulate, you're ready to manipulate, you'll do it and at the same time you must be thinking about what you're doing. If it's a puzzle that you're supposed to do, you're ready to do it.
Researcher:	So they should really be involved?
Cindy:	Yes, that's it! Also, there are cases that you gave a problem and let's say that he's through with the assignment but he was not able to get it. It took him three days, he didn't stop because he was not able to satisfy himself. I couldn't get the answer, *nakakainis!* (disappointing!). Because he even tried it at home, although not in class anymore. (FGI-Beliefs and Practices)

Here, Cindy was elaborating on what she meant by students' willingness to learn. She believed that involvement of students in all activities in class and even after the class was necessary in order for them to learn. She was also emphasizing the importance of a 'hands-on' approach.

In summary, these teachers' beliefs about mathematics learning changed as a result of changes that occurred in their classrooms, for example, after they used the same activities.

Beliefs about professional development

The participants in this study could be considered as novice teachers. The department head, who had the most number of years of teaching experience, was just in her fourth year. Hence, these teachers were using knowledge recently gained in their preservice training. Nevertheless, they believed that there was still a need to make changes in the way they taught the subject.

Initial beliefs about professional development

Before the study started, their thoughts about professional development were focused on inservice training and seeking help from a colleague.

> Yes, maybe. Maybe I need still time, possibly training on how to motivate the students and oh—by seminars. I attended one last year, just one. I used to be a private elementary school teacher, that's why. It was only in 1994 that I came here. (Bert, III-Teaching and Changes)

Seeking the help of a colleague was one way in which they believed they could clarify their thoughts about a certain concept before presenting it in class. This would somehow lessen the mistakes that could be made.

> I need to study more when it comes to mathematics, but I'm trying my best to find a way to improve my teaching. Sometimes I ask the help of my co-teachers. At times the students suffer with our mistakes. (Art, III-Beliefs and Practices)

It appears that these teachers were aware of their professional development needs and welcomed the chance for assistance in this endeavor.

Later beliefs about professional development

After involving themselves in the activities used in the action research, the participating teachers acknowledged that there were several ways to get involved in professional development. They now believed that other forms of professional development could be helpful for their professional growth, especially the ones in which they were involved. In one of the meetings, the discussion went this way:

Researcher:	So, would you say Cindy that inservice would help?
Cindy:	Yeah!
Researcher:	But will this form of professional development also help?
Cindy:	Much better! Because the time allotment, more time to really absorb it. You could absorb what you do and really you could try it.
Bert:	But, ma'am, it s really better to have an inservice which is like this, the one we're doing. It seemed informal. As if we're just telling each other a story. As if there's professional sharing , you're really

> reporting. As if the impact is different, it's *nakakatuwa* ! (good feeling!) (Cycle 3 meeting)

The teachers seemed to view this form of professional development activity as better than the ones that they had previously been involved in. The time for implementation and the professional sharing were mentioned as some of the reasons why this form of professional development activity was preferred over others. This sharing resulted in some novel suggestions. They suggested changing their loads every year or the year level they were teaching, so as to refresh their knowledge of content. Another idea was put forward to conduct demonstration teaching so that everyone could see how certain lessons could be presented to a class.

It was evident that this group valued this form of professional development and had been sharing results with their colleagues. In one of the meetings, they talked about another department in school wanting to experience this form of professional development in the following school year.

This study showed that the involvement of these teachers in the action research activity resulted in broadened beliefs about professional development, although in varying degrees.

Summary

This chapter described the effects of action research as a model for the professional development of a group of mathematics teachers in the Philippines. The effectiveness of the professional development was considered in terms of changing teacher's pedagogical knowledge, practices and beliefs.

This study showed that each of the participating teachers made changes in some ways due to their involvement in action research. In general they became aware that mathematics in secondary schools could be taught in different ways, such as the use of practical work. This was an alternative to the use of blackboard and chalk and teacher exposition, which were commonly employed. As a result of this research, their teaching practices also changed. Sometimes they would use mathematical games instead of the usual practice exercises and would let students work in groups.

These teachers also changed and expanded on some of their beliefs about mathematics, mathematics teaching and learning and about professional development. For example, they changed their view of mathematics teaching from a teacher-dominated approach to one where there was a sharing of learning between the teacher and students. It also appeared that the teachers liked this form of professional development. It could be argued that the use of action research as a form of professional development worked well for this particular group of teachers.

It was apparent from the data relating to individual teachers that change was varied and often quite difficult to pinpoint. It also appeared easier to observe changes across the group in terms of pedagogical knowledge, teaching practices and beliefs.

CHAPTER 6

Constraints to Change

Introduction

This chapter discusses the identified constraints to change and focuses on the third research question: What are the constraints to change when using action research in the professional development of teachers? With these constraints in mind, suggested modifications to the usual process of action research to suit the Philippines situation are suggested.

Constraints

Constraints to change focused on four main areas: personal constraints, classroom constraints, system or institutional constraints and students' constraints. Data were gathered through interviews, observations and from documents. These data were coded and analyzed using the NUD•IST software (Qualitative Solutions Research, 1994). In each of the areas, several categories emerged and discussions follow for each of these categories.

Personal constraints

The data gathered showed that teachers had several personal constraints to change. Three main categories were identified during the analysis: a) knowledge of teaching strategies and content; b) attitudes; and c) awareness.

Knowledge of teaching strategies and content

The teachers' lack of experience in using activities with their students was often mentioned. As most of these teachers were using activities for the first time they found the use of these activities in their lessons difficult to prepare as it was hard to find a variety. Moreover, it was difficult for them to decide which activity would be suited to which type of students or which type of mathematics being taught. Other concerns emerged.

> For me, there's a topic which I find it difficult to make an activity. I don't know if the activity is suited to my topic. (Teresa, Cycle 1 meeting)

Teresa admitted that she had difficulty preparing activities suited to the mathematics she was teaching. This was also the concern of Cindy.

> Yes. Then another thing, you found an activity, it's good, but not suited to the topic. So frustrating! (Cindy, Cycle 1 meeting)

It is clear that Cindy got frustrated when she found an interesting activity which not suited to the mathematics she was teaching. However, in her case, she would share the activity with her colleagues. Difficulty in preparing her activities was also highlighted by Bert.

> Ah, that one I don't like. The preparation, so difficult to do. You would have seen at home, on the table, those are all my things. I'm looking for activities... I really

> have many books there. I'm looking for an idea that is suited to that activity. (Bert, Cycle 1 meeting)

At times, the activities they used in class did not turn out as they expected and they felt that their way of presenting it could be the problem.

> *Naku* (oh, my), on the activities I used, only one helped the students out of the four activities. Because I don't know how to project [present] this. I can do it, but what about the students? The one I don't like, it's so difficult to present the activity. (Art, Cycle 1 meeting)

Here, Art was sharing with the group the difficulty he experienced in using an activity. This could be the reason why he asked the department head or the researcher to demonstrate in his class how a certain activity could be done. Some of the teachers also said that their lack of background knowledge of content and teaching strategies was another reason why they found teaching mathematics difficult.

> Rather than teaching it, just like what you did. You taught that one by guessing, right? Before, to get the equation, I should assign values first. But I don't know that guessing before. (Alex, FGI-Teaching and Changes)

In the above extract, Alex is referring to the activity of finding linear equations from a table of values. This was in the form of a guessing game. It was observed that the students were amazed that the teacher was able to guess their equations. They showed interest and wanted to work out for themselves how it was done. When they were told to observe the completed table of values written on the board, they looked eager to do it. However, after only a few minutes, Alex told them how he did it. In one of his reflections, he admitted that he really had his shortcomings.

> In my teaching, as if there are still shortcomings. I still need to improve. Maybe I really need more practice. (Alex, FGI-Teaching and Changes)

One explanation for the difficulties posed by the changes to teaching mathematics could be that most of the teachers were new to teaching, particularly mathematics.

> Ah, first I'm now happy that I'm in fourth year, although I have difficulties. Honestly, I'm still not familiar with it, but I can teach it to them. Sometimes I would really tell them. I apologized for I was teaching first year last year. Because I'm really struggling. I would say, if there's a problem, okay anyway I'm here, I'm accepting that I made a mistake. Maybe I could accept my mistakes. I'm always like that with my students. But then the way I teach, it wasn't 100% I can give to them. Maybe that's what is happening to me. But almost. I was able to explain it to them well. (Bert, FII-Beliefs and Practices)

Bert described his feeling and difficulties in handling a new subject. It also emerged that he was open to students' comments and aware of his needs. This awareness of needs was also mentioned by Cindy.

> When we had this training before, I did it [the use of activities] too in SEDP, but then maybe I still lack the knowledge on what else could be done. This I wasn't able to do. (Cindy, FII-Teaching and Changes)

It is apparent that teachers had difficulty in using new approaches because they were either not familiar with them and or they lacked the knowledge of implementing them. Being new to this approach exposed difficulties in handling those students who were inquisitive or who would make comments about the teacher's presentation.

> As if he has an idea on logarithm. He was absent when we had that contest. He wouldn't really agree. So, I gave an example. You look at the Meralco bill. If you have 143.53 pesos, the three centavos is disregarded, right? So, that's how I get out

> of it because I couldn't really think of any. But, he was not convinced yet, so when we went out, he talked to some of his classmates. (Bert, Cycle 2 meeting)

Bert was sharing his experience on how he handled questions from an inquisitive student. Certainly, there were students who would not let the session end without clarifying some of their confusions. He shared a similar story during the final interview.

> But there would be a student, for example, he's quiet and just observing. For example, one time you were observing, right? I made a mistake. It's said that it's good to make a mistake and a student would see it. At least you have someone to turn to, somebody who would observe you and say, something's wrong. So this student approached me, sir, as if I'm confused with our lesson now. After that I was able to recall it, it was corrected. Ah , yes, right! See, there I explained that I made a mistake, so I corrected it. Sir, you taught us wrong yesterday. So now I made changes and apologized. (Bert, FGI-Beliefs and Practices)

In Bert's view it appeared that at times he found it difficult to help students who were seeking explanations. However, he seemed open to students' ideas and ready to make changes and apologized when needed.

In summary, it appears that the teachers' lack of knowledge of strategies and content are constraints that inhibit them in making changes to their teaching. The lack of experience in using different teaching strategies, such as activities, and the difficulty with mathematics content were mentioned. The main reason for these constraints is possibly the teachers' limited years of experience in teaching secondary mathematics, the longest was at most four years. Another reason could be the lack of mathematics encountered in their initial teacher training (DOST, 1993; Pascua, 1993).

Attitudes

The teacher's attitude towards change can also be considered as one of the constraints to change. At times, resistance to innovation was observed. For example, an activity was suggested to Alex but this was never tried. During one meeting, Alex displayed his lack of enthusiasm.

Researcher:	How did you do that plotting, something like an algebra walk type? Did you do it that way?
Alex:	The one you mentioned using bottle caps?
Researcher:	Yes, using bottle caps.
Alex:	I don't have the materials. So what I did, I did like this (demonstrated drawing a Cartesian plane) then they were the ones who plotted the points on the blackboard, I did that on the blackboard. (Cycle 2 meeting)

As bottle caps were available at the school canteen, perhaps, the teacher's lack of time to prepare the lesson could be the reason why he did not use the suggested activity. However, in the initial interview he reflected on his unwillingness to prepare his lessons.

> What I will change? My laziness—I'm lazy. I'm lazy in making lesson plans. If I'm doing a demo [demonstration lesson], my lesson [presentation] is complete. I don't have evaluation [portion], if no observer. (Alex, FII-Teaching and Changes)

The ability of the teachers to make changes to their teaching practices may be attributed to the lack of confidence in their knowledge of the subject matter.

> But sometimes I want to try, but then I became negative. It might be that my teaching will fail, right? It's a mistake! Or I would think if it's related to my topic. Sometimes I'd like to do something but I didn't do it because my mind is confused. Also sometimes I have something I'd like to teach, but it seemed I don't know. I would think, what if the students will question me about it? At times my students

> would ask me and I don't know, especially my students in Sampaguita , there are so many of them there that would ask you. (Teresa, FII-Beliefs and Practices)

Teresa hesitated to make changes in her teaching. It emerged from her statements that there were topics which she did not have the confidence to teach. This was due to her perceived lack of knowledge in those topics. Hesitation to try new strategies may also result from the teachers not wishing to deviate from their 'comfort zone'. These teachers were used to a classroom environment in which students sit quietly and remain silent. When students made a noise, either because of a group activity or discussion to clarify a point, teachers often became irritated.

> Students really knew how to evaluate logarithms. Only on the last part of the contest, the teacher was so irritated on the arguments of the students. *Parang lahat sila'y may tanong tungkol sa kanilang mga sagot. Medyo nagalit na nga ang teacher* (It seemed all of them have questions about their answers. The teacher even got quite angry). But Ate Flor said, *gustong gusto nga raw niya 'yon* (she prefers it that way). And even Ma'am Santiago, she said as long as there is learning. Anyway, *naroon si* Ate Flor to help me. (Anyway, Ate Flor was there to help me.) Really students were interested on the said contest. (Bert, Classroom diary)

Evidently, Bert was irritated because of the noise created by students resulting from arguments over the evaluation of logarithms. It is interesting to note that the presence of the observer was not a 'threat' to Bert. Instead Bert would consider the observer as a colleague who would help him in times of confusion.

As observed, the noise created by students occurred mainly when they were trying to get the attention of the teacher so their ideas could be heard. This was explained by Teresa in one of the meetings.

> Too much, they're too noisy, right? As if I'm irritated. You don't know who answered right, because they gave the answer at the same time. Although, you'll tell them that it should be one at a time, the one that I called. Others, because of their eagerness, they would join. (Teresa, Cycle meeting 3)

It appeared that students showed a willingness to participate even when they are noisy. However, teachers found it irritating if students made a noise. Teachers found 'noisy' students difficult to manage. It appeared that these teachers were not used to, or were unfamiliar with strategies to cope with this kind of classroom situation.

In summary, it is apparent that teachers' attitudes are a constraint to change. Some teachers showed their resistance to innovations by not trying out activities that were suggested or by being unwilling to prepare the lessons. At other times, members of the group were hesitant to make changes for these would take them away from their 'comfort zone'. Changes clearly required an adjustment period for both teachers and students.

Awareness

A further constraint to change was the apparent lack of awareness of the changes that could be made. The process of identifying and developing an awareness for change can be seen in the following discussion which was held after teachers watched a video lesson.

Art:	The one which is good first. Here, I changed my style with my students. I saw myself. The first thing, when there was this video session, you saw yourself. So, this is how I teach, that can be changed. (Laughter from the group.) That's true, yes! *Ay* , you would be mad. So it's like this, I was wrong—it should be add the numbers. I didn't change it.
Delia:	You are correcting it based on what it should be.

Art: You saw it, you saw me, ay that's it, I have something to change.

Delia: You realized it?

Art: I realized it. Oh, there is still something to change in me! (Laughter from the group.) I saw myself when I was already teaching... I did like this. Sometimes it's funny and also *nakakainis* [frustrating] when I saw myself.

Cindy: You saw that—

Bert: Something like that.

Cindy: He said: That's what I'm going to remove.

Researcher: Remember, Art before would say: *Ay* that's wrong, that's wrong! Oh, I was able to correct it. [His reaction while watching himself on video, so there was laughter from the group.]

Art: That's it!

Delia: It's better if you took a video. I also enjoyed watching that video. I enjoyed watching that video more than—

Teresa/Delia: Observing a class. (Laughter from the group).

Art: *Ay* because ma'am I saw my mistakes, right? It should be corrected, it should be corrected, then it was corrected.

Delia: That's why I enjoyed the video. (Reactions to video lessons)

Just after viewing himself on video, Art seemed to identify changes that could be made to his teaching. This particular aspect pertained to the mathematical content. He appeared to have presented it in an incorrect way and was not satisfied with his approach.

It is interesting to note that the head of school preferred to observe a lesson through a video rather than in the actual classroom. The possible reason was that, that with a video, episodes requiring more discussions could be played again. Another reason might be, that, with the head of school in the classroom, students would probably change their 'natural' behavior.

The group seemed to agree that there were changes that could be made in the way they taught mathematics. However, they were not aware of what these changes could be until they had viewed themselves on video and reflected upon different possibilities for change.

Classroom constraints

Apart from the language problem, data showed that teachers' willingness to change their teaching practices was often hindered by two classroom constraints, namely class size and space.

Class size would vary depending on the year level (refer to Table 7). For a class of say, seventy students, a teacher found it difficult to conduct group work. In addition, activity work required large quantities of materials.

> Ah, that's a constraint, a real constraint. Firstly, if you let them do a group activity, there's a need to always change groupings, right? For example you have a group activity, so you have to group the students first. Just in grouping them, all the time has been used. Because sometimes you would say, okay group yourselves. The chairs are small, then so crowded and they couldn't move. If they need to stand, you need the time, so the—what's this, is affected. The other constraint is the class size, it's too large. They're too many but the room is small. About seventy five students in a class on the average. (Teresa, FII-Teaching Changes)

Having too many students in a class resulted in students having to stand or share chairs with others for the whole lesson. This situation is shown in Figure 18.

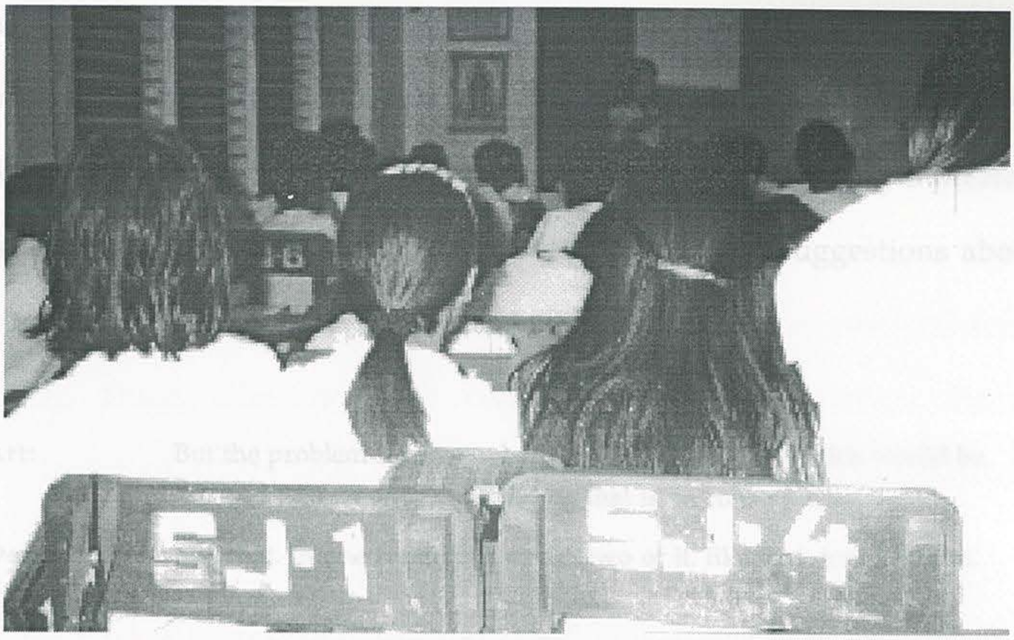


Figure 18: A crowded classroom, some students sharing seats

Large class sizes created other problems. For example, space for movement was limited, which made it difficult for a teacher to monitor students' work during group activities.

> Art: When you're in front—
>
> Delia: You couldn't move.
>
> Researcher: You can't move.
>
> Cindy: So many. You just pass through the middle of the room.
>
> Art: It's so difficult. (Cycle 1 meeting)

Because of the space problem, a teacher could only monitor the work of a few students, say those seated in the front. It was also not easy to store the materials that the teachers and students used in these activities.

> Our problem here is where to put those [materials]. I used to have a graphing board as a project, and when the students have a remedial class on a Saturday, it was lost. (Cindy, Planning meeting)

It seemed that Cindy tried to collect materials which would be useful in the teaching of mathematics. However, in the early part of the study, no materials were seen in her class. She may have stopped collecting materials because of the lack of space. In the later part of the study, suggestions about where to keep these materials were given.

Art:	But the problem for that, where to put it. How I wish this would be finished (referring to the building that is on construction).
Delia:	Not that. In one room, put a nail, two of it, like that, just like that.
Researcher:	Yes.
Delia:	You hang it there one by one. Then you could tell them that it will be you who will use these. If you destroy it , you'll be the one to replace it.
Researcher:	Like that of Teresa. Maybe on that corner, you can put it there, because for one, the students won't touch it. I observed this from Bert's, here. They were not touching it.
Teresa:	Yes, they didn't. Many of that there. (Cycle 1 meeting)

It was observed that when teachers started to use activities in their teaching of mathematics, they kept the reusable materials in the corner of the corridor where they stayed during the break. Keeping the reusable materials with them overcome the problem of losing them.

From the above discussions it is apparent that the teachers had concerns in two main areas regarding classroom constraints. One concerned the large class size which in turn resulted in their second concern, that is, lack of space. With students in a class ranging from 50 to 80, these teachers found it difficult to monitor class activities. Lack of a storage area for reusable visual aids was a practical problem for teachers who were keen to try group activities and new strategies in teaching mathematics.

System or institutional constraints

Four main constraints pertaining to the system or institution emerged from this study. These were the time constraint, lack of materials, heavy workloads and mixed students' groupings. Each of these are discussed below.

Time constraint

The daily forty minutes that were allotted to a mathematics lesson was mentioned by the teachers as being too short a period for teaching. They said that some lessons could not be finished, particularly if they used group activities. Teresa emphasized this issue:

> The time, sometimes what happened, I was not able to finish my lesson because of the activity. Sometimes the activity would be as a presentation of the new lesson, right? Sometimes what happened, we're still on the activity, the time has gone and yet the lesson had not been discussed. (Teresa, FII-Teaching and Changes)

Time management for activities appeared to be a problem. Even though some of the teachers believed that the use of activities was helpful in students' learning, they tended not to use them as often as they wanted because they felt they had an obligation to complete the syllabus.

> We're following the DLC (Desired Learning Competencies). If I couldn't finish the activity, the next day I make it as a review. So what happened, I wouldn't think of other activities because I'll be left behind. So as if that's a constraint. The constraint is really in time. (Teresa, FII-Teaching and Changes)

This teacher claimed she was restrained from using activities because of the Desired Learning Competencies (DLC), which in her understanding, should all be covered. Rather than allowing students to explore mathematical relationships on their own through activities, the teacher would simply tell them the relationship in order to save time.

Teachers identified particular events that reduced teaching time like a sports meet, a periodic test, a drugs symposium and the suspension of classes due to typhoons and flooding.

Delia:	You see, there was a typhoon last week, this week test, next week provincial meet.
Cindy:	How many more, just one month.
Delia:	So, more or less you have to start on the 20, that is, 5 plus 4 days until the 30. On the 30, Bonifacio Day, so no classes. 1, 2, 3, 4, 5, 6, 7, 8, eight days.
Teresa:	Then it will be Christmas vacation.
Researcher:	Our last day for this (cycle) will be before Christmas vacation.
Delia:	Eight days, then considering December. Anyway that last two weeks—(Voices: Christmas Party!) *Ay* there's only two weeks left. But then last week—that's it.
Art:	The *Guronasyon* 29. [*Guronasyon* is an event when the best teacher in the district is given an award.]
Teresa:	Yes, November 29.
Delia:	There's that *Guronasyon*, yes.
Cindy:	29.
Teresa:	No classes for almost a week. The second quarter will just be for three weeks. (Cycle 1 meeting)

It was obvious from their discussions that a lot of class disruptions occurred. Natural disasters such as typhoons would disrupt classes especially when they brought heavy rains and caused flooding. Sports meet, such as the provincial meet may require teachers to attend the event. Public holidays, like the Bonifacio day plus the religious holidays would also disrupt classes. Teachers also mentioned tests as another cause for disruption of classes. Usually, a day before a periodic test, the session would be spent on review. Then a day after the test, a number of students would be absent which would prevent the teacher teaching a new concept, and this session would be spent in marking papers. These interruptions of classes lessened the number of school days, giving the school system insufficient time to achieve its goals and objectives (EDCOM, 1993).

Another problem pertaining to time was the difficulty for the group to find an appropriate time to meet, either to discuss or to consult with each other about the agreed use of activities.

Cindy: Before you try it, our group would discuss about it first.

Teresa: *Ay*, it didn't happen because of our schedule. It's difficult, Ate Flor (Cycle 1 meeting)

Although it appeared that they wanted to discuss with the group their planned activities, they had difficulty finding time to meet together. Their free times were on different schedules.

Considering their statements about time constraints, it appeared that the 40-minute period allotted to mathematics class was not sufficient, more so if activities were used. Teachers found it difficult to finish the syllabus especially with the unavoidable disruptions to classes. The group also found it difficult to find time to be together because of their conflicting schedules.

Lack of materials

The school had neither a library facility nor a mathematics laboratory when this study was conducted. It was not surprising then that teachers would mention the lack of materials as one of the constraints preventing change to the way mathematics was taught.

It was brought to the notice of the researcher that even the mathematics textbook for fourth year students was not available. To reduce this problem, the fourth year teacher formed groups of students and each group would 'donate' one mathematics book as part of their project and made these books accessible to all students.

The school did not provide teachers with the materials needed for the activities. Moreover, to buy the materials from their own budget did not seem to be a reasonable way of solving the problem.

> And sometimes, too, there's one that I would like to use but the materials are expensive, so that a real constraints. (Cindy, FII-Teaching and Changes)

If only materials and activities were provided, teachers manifested eagerness to make changes to their teaching. Another statement from Cindy attested to this.

> That one, the one where you have to connect the sticks. I said it's good to do it, but I can't, no materials. It's really frustrating! (Cindy, Cycle 1 meeting)

At the early part of the study, Cindy verbalized her frustrations, but this did not prevent her active participation. Teresa also indicated her concern by writing on her diary a request for supplies.

> May I request for some ready made materials and some activities with regards to the lessons presented. (Teresa, Classroom diary)

Because of the lack of materials, some students would be left with nothing to manipulate whenever an activity required them to do so. This is shown in Figure 19.

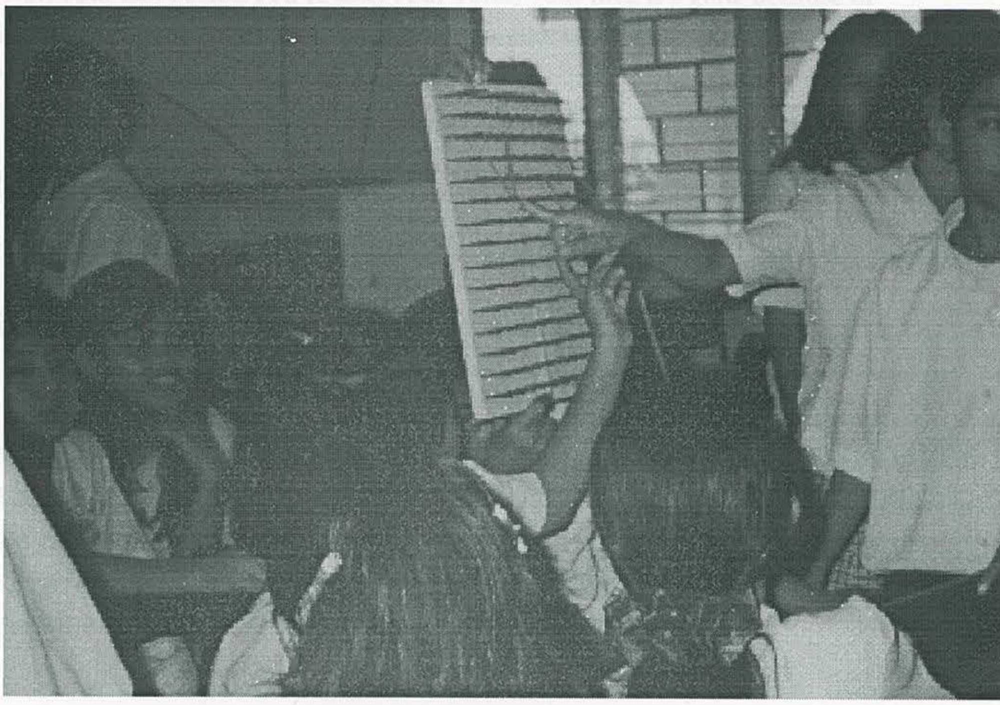


Figure 19: Some students not participating because of lack of materials

It appeared to be an ineffective use of time for those students not involved in the activity, for they were attending class, but the learning that took place was questionable.

It emerged from this study that the primary concern of these teachers regarding materials was their availability and accessibility.

Heavy workloads

Teacher's workload refers to their teaching loads and participation in other school activities such as scouting and sports training in which they were expected to be involved. These teachers said that their heavy workload, usually at least 5 hours of teaching a day, affected them physically.

> So on your last period you're like, your voice, your idea it's gone because of tiredness... Come night time, you would be like vegetables which were not fresh. When you're in bed, that's it! (Art, IGI)

This heavy workload affected their preparation of lessons. The time to read and look for activities suited to the lesson, and the time to prepare the materials for the activities, were really a concern to them.

> You have seen our assignments—so many! I have assignments in math, then in THE [Technology and Home Economics] I have two. Just preparing the materials so that you can present it, the time is not even enough. It's different when you're prepared. It's not enough that you know it, you should have other ideas so that when you're there the students will readily accept it. (Alex, FII)

Alex had two course preparations, one in mathematics and the other in technology and home economics. He was very concerned about the lack of time to prepare the materials. More time would have allowed him to make the necessary preparations that would have benefitted his students. Two other teachers voiced similar concerns. They felt that preparing activities needed time, which they lacked.

> Ah, for me, mostly the constraints will still be on the preparation. For example, I'd like to do it, but you know that we have 9 loads, it's really difficult for me. We really don't have the time to do it. At home, suppose to be this is our time to rest, but we still prepare the activities. You even observed it, that really time is not enough. There's really a need, maybe, for prepared activities suited to what we will do. The

others are quite complicated [referring to the activities in the PASMEP Resource Book]. Some, I couldn't get it. (Bert, FII)

Apart from the constraint about time, Bert seemed to suggest that it would be better if there were prepared activities similar to those in the PASMEP resource book. However, he suggested that the resource books should contain simpler instructions to follow.

The teacher who had the least teaching load was required to do work other than teaching. Being the department head she had other commitments and assignments to fulfill.

One would be my extra work, those office work suppose to be, that's one. I really have a lot of paper works. Scouting is another, that's just in school, I have a lot of paper work. At the same time, because of those paper works, I couldn't have time to read for the activity that could be done. So what ever book I'm holding, I'll just look at it, that's it. That's really the constraints for me. (Cindy, FII-Teaching and Changes)

Heavy workloads were another important constraint to change. A heavy workload left teachers with less time to prepare lessons. Moreover, the heavy workload was physically tiring.

Mixed students' groupings

Students in this school were grouped with mixed abilities, except for one group per year level which was composed of students selected based on their academic standing. This system where students of mixed abilities were put in one class was viewed by some teachers as causing difficulty in classroom management.

Researcher: In your teaching, did you encounter problems?

Teresa:	Teaching mathematics, yes. Because sometimes, the level of the students are not the same.
Researcher:	Is it not homogeneous?
Cindy:	What happened, if your handling the bright section and you also have the lower section—
Teresa:	You know they're left behind
Cindy:	Others are left behind.
Alex:	You kept in going back [to the topic].
Art:	Go back [to the topic]
Cindy:	You would sometimes have different lessons...
Teresa:	Sometimes—example, in your lesson plan you can't execute it on the lower section.
Alex:	So sometimes in our lesson plans, you use it twice, you have to repeat the past lesson.
Bert:	The lower sections are behind...
Teresa:	Examples in the preparation of test, the evaluation for the lower section would be different. (IGI, Teaching and Changes)

The teachers' teaching strategies, language used, and pacing of the lessons were some of the issues that they argued were affected when their students were in groups of mixed abilities. Even when the study progressed, teachers still found difficulties with this form of grouping.

Students' constraints

In looking at the different constraints that affected teachers' willingness to make changes in their teaching, one significant category was related to the students. Three main views about the students emerged from the data that were collected. These were the students' mathematical background, attitudes and language problems.

Background knowledge

Students' mathematical background knowledge created a problem for teachers trying to make changes in their teaching of mathematics. They observed that some students lacked the necessary skills and background knowledge to understand the concepts that were discussed in their year level.

> In mathematics learning, I have a problem. This one could be an outside factor, but especially with the first year, even the basic four fundamentals, you still have to teach them. Instead of discussing the first year lesson, you would keep on coming back to these. Majority of them especially the lower sections are like this and we observed them about their needs when we administered a test to find out who would need remedial classes. (Cindy, III-Beliefs and Practices)

It was felt that a review of the basic operations in mathematics was needed especially for some of the students entering high school. Art agreed to this.

Art:	And also, what I noticed with the students, simple division, they're confused. That way.
Delia:	So, what—
Art:	So, I have them try to solve, twenty four divided five. They were not able to get it. Even the basic, others couldn't get it. It took me 30 minutes for that student on twenty four divided five. (Cycle 3 meeting)

From the comments of these teachers, the students' background on basic mathematics appeared to be a major concern.

Students' exposure to different teaching strategies was also a factor considered by the teachers. For most of the time, the usual classroom environment consisted of students listening to teacher's discussion. Changing this environment, for example, by allowing students to work in groups and using manipulative materials for the activities, created an unusual setting for students. Cindy mentioned students' preparedness in using particular manipulatives.

> As if the ..tudents are not yet ready for such complicated activity, so you really have to find the easiest way, the easiest possible way so they can get on with the activities. (Cindy, FII-Teaching and Changes)

The use of algebra tiles in mathematics was apparently new to students. If these had been used before, say in introducing variables or special products, then finding factors of trinomials using these algebra tiles may not have been as difficult for students as it appeared here.

> The students were able to get the dimensions, at least three of these. When they were dealing with negative tiles, they need the guidance of the teacher. The concept of zero in the algebra tiles was confusing to them, but once they understood they were able to form on their own. It also took a little longer than it was supposed to. (Cindy, Classroom diary)

Bert had a similar problem with his students when he allowed them to use calculators in one of the activities.

> The output was okay since one of the groups got the secret message or the answer. There was only a slight problem in using calculators. Some students do not know how to use calculator especially on square root/cube root. (Bert, Classroom diary)

It was observed that only a few students had calculators. This could be the reason why students were not familiar with some calculator operations.

Students' lack of experience in group work also posed management difficulties for the teachers.

Cindy:	Sometimes it's composed of friends. Sometimes you would have them count but this is time consuming and by the time they form groups, what a noise!
Teresa:	Before they go to their seats or their groups, what a noise!
Cindy:	So difficult to have them go to their groups and sometimes the good ones are in it. If they're together, it's not good.
Bert:	But what happened, they would count, 1, 2, 3, 4. But they won't go to their number. Of course, you wouldn't remember it all. Now they'll go to the group where the good ones are there. As if they're hiding on those good ones. That's what had happened.
Cindy:	They're dependent.
Bert:	That's it! They're dependent. Ah , I'll be with the good ones so that I can make it. (FGI-Teaching and Changes)

These teachers observed that having the students form groups was initially time consuming, created a lot of noise and encouraged dependency for some students. The lack of experience with other teaching strategies was also apparent.

Comprehension of instructions was considered by the teachers as a concern particularly when using activities. Some of the teachers mentioned that this could be because instructions were not clear and because students were not used to following instructions on their own.

> But there are times that the students are not ready for the activity. What I mean is, those terms, especially if those are directly lifted from a book, there are words which they don't understand. Those directions, on how to do it, if you're going to write it on a manila paper, won't explain it, leave it as is, they will come to you and ask you each of those. So, what happens, if there's a manila paper and you wrote there something, you have to explain everything in details on what they're going to do. They have difficulties on the comprehension of directions, especially on the lower section. Maybe if they'll be used to it. I noticed in *Ubas* [Grapes, a name given to a group of third year students] the first time, there was really too much noise. Ma'am, what's this; ma'am what are we going to do here? But now, they're not like that, as if they've been used to it. (Cindy, FII-Teaching Changes)

It appeared that instructions like those lifted from the book, which are in English, posed difficulty for students to comprehend. However, there was an indication that students' reactions changed and that they were getting used to understanding instructions on their own. The type of questions asked in class also affected students' answers. In one of the group meetings, this issue was discussed.

Bert: You change the questions.

Cindy: Adjusting the questions. Sometimes this happened that it appeared to the—that's it. There are those who gave an answer. So, that was right and I said: Show it here on the board, so it became a connotation to them the 'show me'. Always, ma'am show me, show me. Consciously, I changed this word. Everytime I almost say it, I bite my tongue. Because the connotation would be. *Naku* , I need to prove it, I have to show it there then explain. This seemed to be negative to them, so what I did I always make changes on the follow-up questions with why. Now, they're used to—if you give an answer to ma'am, it's followed by why. I had this experience before. I asked him: Are you sure? He gave a new answer. Are you sure? I wrote it. They changed the answer. So I kept on writing.

Delia: It meant something.

Cindy: So I told them: there's only one question. I asked you, are you sure and you gave another answer. How many changes did we make? Did you count it? Ma'am, so many. Okay. You, of all the answers given here by Allen, which would you choose?

Art: Or they could have another answer. (Laughter from the group.)

Cindy: Yes! I said, which one would you choose. So, the first one I called, he's quite good. Ma'am, the first one. Why this, I asked him, why this? I already spoke to them in Tagalog so that we would understand each other. He said, ma'am that's really what is right. He explained it, at least he explained it in Tagalog. Okay, use Tagalog. Really that is what is right, like that, like that. So he explained. Then the other one said: Ma'am, so its right. Yes, its right. So, ma'am why did you ask us? I asked you to make sure. Why did you change your answer, I asked them. (Reactions to the video lessons)

It emerged from this discussion that, at first, some students were not ready to answer questions requiring analysis. This indicates that students were new to a teaching approach that involved higher-order level questions. These students were used to a method where, if their answer was correct, the teacher said so. If it was not correct, the teacher would say something like "Are you sure?" and the student would give a new response. Now, when the teacher said "Are you sure?", this required the students to think about the answer and respond with something like, "Yes, because..." or "No, because...". This was a new strategy, a questioning technique which required students to think and adapt.

It emerged here that the students' lack of some basic skills was seen as a constraint by teachers wishing to make changes in their teaching. They said that the students lacked the prerequisite knowledge and skills needed for that particular year level. Also, as students and teachers were new to the strategies used in class, both needed time to adjust. Students also needed guidance in the use of manipulatives and group work activities.

Attitudes

The observed attitude of students towards mathematics was another problem for the teachers in making changes to their teaching of mathematics. These teachers observed that students do not like mathematics and that they seemed to think they were not good at it. The teachers have a strong perception that their students have negative attitudes towards the subject.

> They don't have the initiative. What they know is that, it's math and they are scared of it. They're not aware that all problems have solutions. (Teresa, IGI-Beliefs and Practices)

Teresa observed that some of her students are 'scared' of mathematics and would not show the initiative to solve a problem. Bert had a similar observation.

> So maybe they are not inclined to it , as if they don't like math, something like that. I would really like to encourage them to listen to me, as if they don't like. Like for example, you're teaching like that, right? Sometimes you would see them, they're looking at me but they're not listening. That's what I observed, no matter what I do, even though I talked to them about it, still I couldn't convince them. So you could really count the good ones, you'll notice that they'll keep on asking questions. (Bert, FII-Teaching and Changes)

The reasons for the attitudes of students who showed signs of discomfort in mathematics were described by the teachers. Teachers observed that some of their students had the habit of making guesses without basis when asked for an answer to a question. They would even keep changing their answers when prompted by further questions. They would not participate actively in discussions nor ask questions to the teacher. Teachers described these students as shy, uncooperative, lazy or lacking perseverance.

Language

Mathematics in the Philippines is taught in English whereas students from this school speak Filipino. Thus, language emerged as a constraint to change. During the initial interviews, the problem was identified by one of the teachers.

> Because the usual problem in math, English is the medium of instruction, so sometimes you'll be forced to speak in Filipino or else they would not understand. (Cindy, III-Beliefs and Practices)

The use of Filipino language is often used in teaching mathematics. It was often observed that students could not proceed with a given activity because of their difficulty in understanding instructions. Teachers were often obliged to give further instructions, sometimes using two languages, Filipino and English.

> Usually, if an activity is given to them, especially if the students are not familiar to these, even the instructions are difficult for them to follow. They kept on asking me about the instructions. Just like the Cartesian activity, it took us 30 minutes to discuss the instructions alone. (Cindy, III-Teaching and Changes)

Cindy was giving an example of an activity she used where students found the instructions difficult to follow. She was referring to the outdoor activity where students were to walk a number of paces to simulate the plotting of points on a Cartesian plane. She said that it took her 30 minutes just for the instructions. This could imply that the group of students would find it more difficult to understand the activity. So, she had to use a different approach with another group of students.

Cindy:	Usually your approach to the higher section would be different when you go the lower section. Because the one that you used in the higher section couldn't be absorbed [by the students] in the lower section.
Teresa:	So really you need to use Tagalog [referring to Filipino language] in the lower section. (IGI-Teaching and Changes)

Teachers stressed their difficulty in giving instructions to students. They indicated that too much time was spent on helping some groups of students to understand. Art discussed this in one of the interviews:

> They have the individual differences, there are those who can easily understand and those with difficulties in understanding. One of the reasons why the students now, when it comes to math, you let them explain, even simple English they don't understand that's why I use Tagalog . I use bilingual, Tagalog or English, as long as they understand. (Art, FII-Teaching and Changes)

It is evident from the teachers' statements that language was a constraint to making changes particularly in situations where lengthy explanations were required, for example, with activity work. Giving instructions became a time consuming activity especially with certain groups of students.

The use of English discouraged teachers from involving students in long discussions or lengthy instructions, whereas, using Filipino helped overcome these concerns.

Changes to the action research process

Despite the constraints, all the participants in the study were able to complete the action research program. From the group's experiences, several implications on the use of action research as a form of professional development were identified. This section will discuss the answer to the third follow-up research question about possible changes to the action research process to suit the context of the Philippines.

In the usual action research process, there are several stages which the participants would go through: planning, trialing of plans, reflecting and evaluating and revising the plans. The implementation for each of these four stages will be considered.

Planning

In a successful planning stage, it appears that there is a need for an instigator for the project. The instigator could be anyone, a classroom teacher, the head of school, the department head, or the mathematics supervisor, to name a few. However, because of the school culture in the Philippines, unless this instigator has the support of someone 'in authority', teachers would be hesitant to participate in the activities unless they were endorsed by the school authorities. To get the support, the instigator or anyone with a knowledge of action research could give a brief description of the process and discuss expected outcomes. In a small department such as in this school with only nine mathematics teachers, the participation of everyone would have been more effective. This way greater cooperation and commitment may ensue.

The time for the group to get together for planning was difficult to arrange because of the different schedules of free time. Planning meetings were only possible during recess times, in order to avoid disruption of classes. However, the fifteen minutes' recess break was not enough to have a quality discussion over an issue. Lunch time for teachers would vary depending on their free time. One possibility would have been for the teachers involved to sacrifice a weekend, say a Saturday, for the initial planning meeting. Another possibility would have been for the group to inform the principal of their plans well ahead of time. In this way, timetables of teachers may be arranged to enable meetings to occur.

Trialing of plans

The trialing of plans needs continuous monitoring and discussion with all members of the group. If possible, teachers handling the same year level of mathematics should continuously consult one another. For example, with the group of teachers involved in this study, it was helpful when a demonstration lesson was taken showing how an activity could be used in the classroom.

Reflecting and evaluating

In the reflection and evaluation stage, a list of topics as a basis for discussion should be prepared. This would guide the group and properly manage the time allotted for the discussion during meetings. The use of either Filipino or English, whichever the participants prefer, could be encouraged in the discussions or in the writing of diaries. Participants could use their diaries to give suggestions on focus areas.

Revising the plans

Based on the reflections and evaluations, the group would decide on the changes to be made or what would be done the next time. A copy of the revised plan could be distributed to each of the participants. This could serve as a reference as to what they had agreed upon for the next cycle of action research.

It is apparent that minor changes to the action research process are needed. Some of these pertain to the culture of the group, the language used and school policy. For example, the existing policy about prevention of unnecessary interruptions of classes (Appendix P) could be revised to make it clear that professional development programs may be viewed as a necessary teachers' activity, and that the conduct of group meetings may be authorized for the purpose of action research programs. Despite all the shortcomings the group had experienced, it has been found that the stages in the action research cycle could still be useful guides for teachers willing to participate in such a program.

Summary

In this chapter, the constraints to change when using action research in the professional development of teachers were identified and categorized into four main areas. The first one was personal constraints such as teachers' perceptions of their lack of knowledge of some mathematics content and different teaching strategies. The second one was related to classroom constraints. With class size ranging from 50 to 80 students, overcrowding made it difficult for the teachers to implement change such as the use of group work. The educational system was another area identified as a constraint to change. Lack of time, availability of materials and heavy workload were some of the concerns mentioned. Lastly, concerns relating to students, such as their background knowledge, attitudes and language problems were identified.

It is apparent that the participants in this study were faced with some difficulties in completing the action research. However, the experiences led to suggestions about possible changes to the action research process to suit the Philippine context. It emerged that for a group of teachers to complete an action research more effectively, there was a need to consider several points. Firstly, in the planning stage, it would be helpful if one in the group, with a knowledge of action research and who also has the support of the 'authority', could act as an instigator. In the trialing of plans, class observations and discussions with all members of the group would facilitate the implementation of the plans. These activities enable the teachers to clarify their ideas on how the plans would be implemented and also appeared to be the stage where they considered much learning to take place. During discussions, and in their diary entries, the use of the teachers' preferred language, either Filipino or English, should be encouraged. In the revision of plans, it is helpful for everyone to have a copy of the plans that had been agreed on as a reference for the next cycle.

Indeed, the constraints identified by the participants affected the changes they wanted to make in their teaching of mathematics. However, it could be argued that the experiences they encountered in this study made them more reflective teachers and helped them grow professionally.

CHAPTER 7

Conclusion

Introduction

This chapter will discuss the conclusions and the implications of the findings of this study on the classroom practices and professional development practices of secondary mathematics teachers as well as suggestions for future research in this area.

Conclusions

Conclusions here will be made about teachers' needs based on results from the questionnaires that were given to teachers, department heads and PASMEP teachers from all over the Philippines. Concluding observations will be drawn from the action research carried out by five participating teachers in one particular school in the Philippines.

Teachers' needs

This research found that teachers perceived a need to make changes in the way mathematics is taught. Most teachers mentioned changing their teaching strategies from single reliance on the use of board and chalk. The use of technology such as computers in the teaching of mathematics headed the list of strategies that were sought. Following the list were the use of group work, mathematical investigations, practical work, games, visual aids and problem solving. Nevertheless, there were also teachers who commented that they saw no need to make changes in their teaching practices; rather, they would like changes to happen in the educational system such as reduction in class size and increasing the time allocated for teaching mathematics.

It was noted that teachers were willing to participate in professional development programs mainly for their professional growth. They believed that whatever they learned in such programs would benefit them and could be shared with their students and co-teachers.

This research also found that the PASMEP teachers believed that seminars, workshops or inservice training would help in the professional growth of teachers. They found these to be successful in terms of enhancing teachers' professional growth.

The department heads believed that professional development programs conducted in their respective departments led to changes in the way teachers teach. If further changes are to occur in their departments, they would like them to be centered on the use of technology such as computers and overhead projectors. Department heads were hopeful that it would not be long before their teachers were using these new technologies.

It was noted that teachers, department heads and PASMEP teachers mentioned seminars, workshops and inservice trainings as the professional development activities that were conducted in the past. This was a limited choice of professional development activities with no mention of action research as a form of professional development.

The action research

Effects of action research on teacher's professional growth

The results indicated that the involvement of the five teachers in the action research had an effect on their professional growth. There were noticeable changes in their pedagogical knowledge, teaching practices and beliefs.

There was a variation in their teaching strategies. For example, practice and consolidation strategies no longer relied on just pen and paper seatwork; they used games or contests as well. Different teaching strategies were used such as practical work, where teachers used different visual aids to demonstrate the concepts, requiring students to manipulate these visual materials before discussion. Routine exercises and activities were at times done in groups, giving students the chance to discuss among themselves possible answers to problems or questions. Answers to assignments were no longer shown on the board except for items that most students did incorrectly. They became aware that they could use teaching strategies other than the chalk and board in teaching mathematics.

As a result of the teachers' involvement in action research, they became actively involved in different professional development activities. These activities were in the form of workshops, class observations with peers, group discussions and consultations with colleagues, the head of school and the researcher.

This research found that the beliefs of these five teachers about mathematics, mathematics teaching, mathematics learning and professional development also changed as a result of their involvement in the action research. In relation to mathematics, their beliefs about its importance were mentioned throughout the study and their view that mathematics was computation and problem solving appeared to have changed. In the later part of the study, they discussed other aspects of mathematics such as analysis and games. In terms of mathematics teaching, teachers changed their beliefs from that of 'transmitting' or 'supplying' knowledge to students, to that of a 'give and take' situation between teachers and students. They said that teachers should act as facilitators. For mathematics learning, teachers believed that this depended mainly on students' attitudes and teachers' commitment to their responsibilities. At the start of the study, they believed that for students to learn, they needed to listen and be attentive to the teacher's lectures or discussions. However, later in the study they said that mathematics learning resulted not only from the lecture and the 'chalk and board' method but also from students' active participation in activities; that is, they saw the advantages of a 'hands-on' approach being used. Regarding professional development, no change in their beliefs could be concluded as previously they were not involved in a lot of professional development activities except for inservice training and seeking the help of a colleague. But they clearly recognized the enhancement in their professional growth when they were involved in different professional development activities during this study. It was also evident that the changes in the teaching of these participating teachers were noticed by teachers from another department. Plans for a similar professional development activity were in progress. This indicated that there was a possibility of sustaining this kind of professional development activity. This was the challenge posed by McTaggart (1996) to teachers who were involved in a network of action research programs throughout Australia. He argued that action research was worth sustaining especially when resources in schools were declining.

This research found that the degree of professional growth of each of the participating teachers varied. Nevertheless, each one of them changed positively in their teaching practices and attitudes as viewed by the researcher, the head of school and themselves.

While it was apparent from the data that the individual teachers made a variety of changes, these were quite difficult to pinpoint. It appeared easier to discern changes in terms of pedagogical knowledge, teaching practices and beliefs of teachers across the group.

Constraints

This study identified four major constraints that made it difficult for teachers to make changes in the way they taught mathematics. These were personal constraints, classroom constraints, students constraints and system or institutional constraints.

Regarding the personal constraints, it was found that the teachers' deficiencies in aspects of mathematics content, their knowledge of the different teaching strategies, their attitudes, and their awareness of what to change in themselves, were some of the problems that they faced when trying to make changes. Being new to teaching mathematics and teaching a particular year level of mathematics for the first time, they had difficulty in adjusting to the teaching situation. Their experiences in using different strategies were also limited and some of them tried activities for the first time during this program. Resistance to change was also observed. For example, an activity was suggested but they would not try it perhaps because of the preparation and their hesitation to deviate from their 'comfort zone.' Another problem was that some of them were not aware of what changes could be made and they only knew about the possibilities for change when they viewed themselves teaching on video.

This research also noted that teachers hesitated to make changes in their mathematics teaching because of class size and classroom space. For example, in a class of say, 60 students, these teachers found it difficult to let the students do group activities in a small room. Monitoring students' work and finding a space to store the manipulative materials were additional problems.

It also appeared in this research that constraints pertaining to the educational system also caused problems for these teachers. The time allotted to a mathematics class, availability of materials for students to use, teachers' workloads and students' groupings were the main constraints mentioned by the teachers. In the case of the teachers that decided to include the use of manipulative activities in their teaching of mathematics, they encountered more problems. The 40-minute lesson was found to be too short if they used activities, materials were not enough for the number of students, and their heavy workloads would not allow them to have enough time to prepare activities that would suit the kind of students they were teaching.

This research found that these teachers considered the type of students that they had, also posed concerns. The students' background knowledge, attitudes and language used were the main difficulties. These teachers observed that some of their students lacked the prerequisite skills to understand the mathematical concepts discussed in their year level. They also perceived that their students had negative attitudes towards mathematics. Comprehension of the instructions using the English language also posed a problem for they were asked for more explanations to some instructions and some would even hesitate to answer for they had difficulty expressing themselves in English.

In summary, although this form of professional development activity appeared to face several constraints, it can be argued that it was found to be effective because it positively changed the practices, beliefs and attitudes of the teachers towards mathematics teaching. The probable reasons for the programs' effectiveness can be attributed to:

- the active participation of teachers because it was their own problems that were being solved (Clements & Ellerton, 1996; Lovitt et al., 1990)
- not relying on a one-shot approach but rather a continuous process of change (Borchers et al., 1992; Lovitt et al., 1990; Mousley, 1992)
- interruption of classes was minimal
- minimal budget involved; that is, no accommodation cost, transportation cost, etc., so access of everyone to this form of professional development activity was possible.

Limitations

This study had certain limitations. Firstly, in the conduct of the pilot study. This was done in Australia which resulted to items in Questionnaire H not answered for these were relevant to Philippine context. During the planning of this pilot study, there was a perception that it would be better to conduct it in the Philippines. However, the following arguments were considered:

a) In finalizing the instruments for the main study, immediate feedback and guidance of the supervisor were needed. With the communication problem between Australia and Philippines at the time of the pilot study, it would have been difficult to come up with the final instruments to meet the timeline for the main study. The data gathering was planned for almost a school year. Delaying this pilot study would have an effect on the timeline of the data gathering. This could have resulted in a shortened period of research making it difficult to complete several cycles of action research or making the research much longer because of the waiting time for the next school year to begin.

b) The questionnaire items relating to the Philippine context were minimal compared to the rest of the items which could be answered by any secondary mathematics teacher.

c) The class observations would focused on how to document teacher's way of teaching and not to come up with discussions on the changes made by the teachers on their teaching. In this way, the researcher was expecting to gain insights on the methods of recording observations rather that what were observed.

In the conduct of the main study, questionnaires focused on the needs of teachers pertaining to the way they teach mathematics and not on their deficiencies in mathematics content. It was perceived that teachers wanted to work on aspects of their teaching practices not on their content deficiencies. So, the concentration of this study was mainly on the teachers' changes to pedagogical knowledge, teaching practices and beliefs.

In assessing the teachers' needs as viewed by the three groups of participants (teachers, PASMEP teachers and the department heads), no follow-up interviews were made to supplement the questionnaires. Results of this part of study were mainly for the purpose of getting ideas on the teachers needs in order to assist in the planning of action research. Thus, a need for follow-up interviews was not perceived as essential.

In the action research part of the study, the sample size was limited to five teachers—four representing the year level of mathematics they were teaching, plus the head of the department, together with the head of school and the researcher. It was decided that there would be one representative per year level rather than all from one year level because of the following reasons. First, the focus of the study was on the changes made by the teachers on the way they teach and not on the mathematics content. Thus, teachers would be able to discuss, with the rest of the group, the way they taught, no matter what year level of mathematics they were teaching. Second, the results would be more generalizable to high schools where a range of classes were used.

Although, with the sample size involved, it would not be appropriate to make generalizations from this study, an understanding of how this group went about doing an action research program can provide insights and possible implications for others wishing to undertake similar programs.

Several instruments were used for gathering data. However, the use of some of the instruments had limitations. For example, in the video recording, the camera was usually fixed when used in class. This was to avoid distracting students. This resulted in some of the relevant and important episodes not being recorded. Another was the keeping of a diary. Not all reflections were entered.

Guskey (1986) stressed that the learning outcomes of students is considered as one of the major components in the evaluation of the effectiveness of a professional development program. In this study, students were not included in the sample. The research mainly focused on other important outcomes of professional development— changes that the teachers made when they participated in a professional development program, in this case, an action research program.

Understanding the potential of action research requires looking closely at its personal, professional and political dimensions (Noffke, 1997). In this study, the emphasis was on the personal dimension. It was more about looking at changes made by the participants in terms of enhancing their knowledge, fulfillment in work and understanding their own practices.

Implications

Implications for teaching and professional development and for further research will be discussed in this section.

Implications for teaching and professional development

It is apparent from the results of the survey of teachers' needs that teachers wanted reforms in the way they teach mathematics. They also showed a willingness to participate in professional development programs for professional growth. There is a clear indication for a need to plan professional development programs that will address these needs of teachers. This could also indicate a need to rethink the mathematics education needs of preservice teachers.

Teachers involved in school-based professional development program made significant changes to their pedagogical knowledge, teaching practices and beliefs. This showed that bottom-up professional development program is workable with a particular group of teachers in schools. School administrators should encourage their teachers to take the responsibility of their own professional development through involvement in the planning and implementation of school-based professional development programs.

This study has shown that action research is a practical and valuable professional development activity for teachers. There is an implication here that action research among teachers be introduced or adopted as their professional development activity. Strategies for encouraging them to be involved could be planned.

Another area that was considered in this research was the constraints that these five teachers faced in implementing the changes that they made. The teachers' concerns were found to be mainly personal and also those which concerned their students, classrooms and the educational system. Some of these concerns had been identified by Ulep (1993) as problems in the teaching of secondary mathematics in the Philippines. These identified constraints could be taken into considerations when planning professional development programs.

Implications for further research

Teachers from all over the Philippines were mostly concerned about changing their teaching strategies to include more than just the use of blackboard and chalk. They would like to use educational technology, particularly computers. Although this need appeared to be at the top in their list of needs, the group of five teachers who undertook this action research did not work on this need, despite the availability of computers in their school. Rather, they decided to work on the use of practical work as a teaching strategy which was based on their own needs. A future study, to investigate effects on teachers' professional growth, where teachers identified other strategies, for example, the use of computers in teaching mathematics, could be undertaken.

It is apparent from this research that professional development activity for teachers focusing on their own needs can have an effect on professional growth. However, a follow-up study for this group of teachers could be undertaken to find out if the changes they made to their teaching routines is of permanent nature as a result of their involvement in the study.

This study involved the active participation of teachers in the identification and design of solutions to their teaching concerns. This confirms the view that professional development activity that is "bottom up" as mentioned by House (1994) and Lovitt et al. (1990) is likely to have positive results. However, it remains, for further study, to see how effective it would be if the teachers were left to carry out the program themselves, that is, without the presence of a facilitator, in this case the researcher.

Through this study, it was noted that theoretical action research and practical action research can be achieved, however, it would be appropriate to extend this research to find out if emancipatory action research is as successful. This would be achieved if significant changes occur at the systems level, resulting in such changes as workload and class size. Also, other dimensions of understanding action research, as mentioned by Noffke (1997), such as the political dimension, could be other areas for further research.

One of the most interesting aspect of this action research concerned the budget. There was a minimal budget, except for the workshop which involved mathematics teachers from other schools, yet there was a significant change in the teachers' professional growth. These changes were significant in relation to their pedagogical knowledge, teaching practices and beliefs that were documented using different ways and from different views as discussed in this study. It may be worth further investigation to measure the degree of professional growth these teachers achieved compared to changes resulting from other more, costly forms of professional development activities.

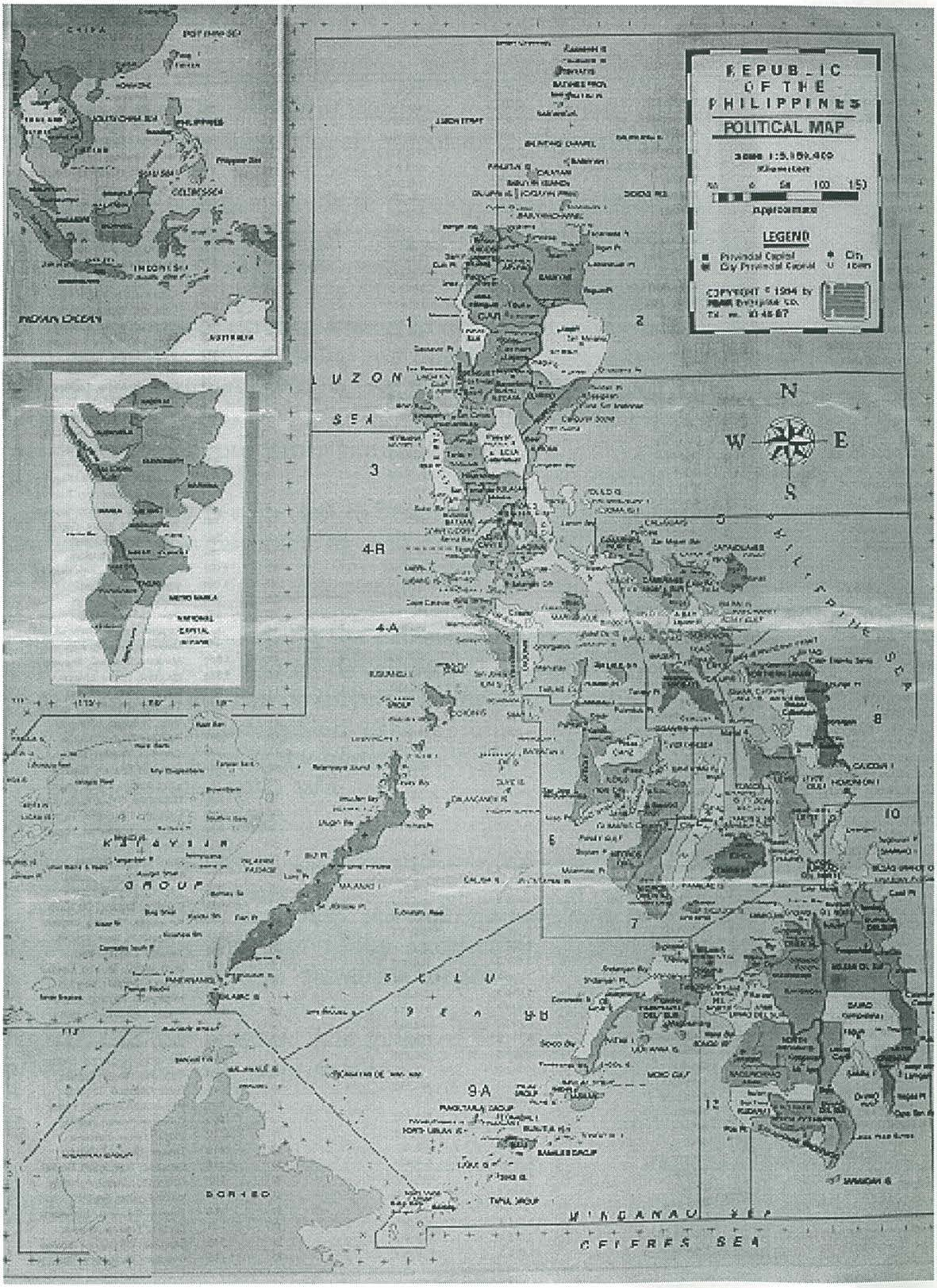
Each of the participating teachers made positive changes in their teaching practices and attitudes as viewed by the researcher, the head of school and themselves. However, the views of the students about the effects of these changes were not sought. This could be another area for future study.

Teachers identified mainly personal constraints in implementing the changes that they made. These constraints such as those concerning students and educational system could be another area for further research in secondary mathematics teaching and teaching in general.

Finally, the research has demonstrated that the action research process as described by Kemmis and McTaggart (1988) could be carried out by a group of secondary mathematics teachers in the Philippines. This form of professional development had a positive effect on teachers' professional growth. It was also quite different from most of the professional development programs conducted in the Philippines (ISMED, 1991; 1994; PASMEP, 1990). These were often held in venues where budget costs such as accommodation and transportation are high resulting in only a few teachers having access. Furthermore, areas of the training may not be the ones that are needed in the school from which the teachers come. It would be worthwhile then for professional development designers to look more closely into forms of professional development activities including action research, that directly address the needs of the teachers.

Appendices

Appendix A Map of the Philippines



Appendix B Teacher's consent form for the pilot study

To the participants:

I, Florenda L. Gallos, a PhD in Mathematics Education student of Edith Cowan University in Perth, Western Australia, will be doing a research project on professional development of mathematics teachers.

The purpose of this study is to develop, trial, evaluate and document a school-based professional development model for secondary mathematics teachers in the Philippines.

In order for me to do this, I need to do a pilot study here in Perth. The purpose of this is to develop my questionnaires, interview forms and observation guides. I will be requesting you to answer a questionnaire, observing your classes for at most three times and interviewing you which would take us about thirty minutes.

This pilot study is expected to benefit you in gaining knowledge on professional development as well as giving you the chance to work with colleagues.

Any questions concerning the project entitled **Evaluating a model for school-based professional development of secondary mathematics teachers in the Philippines** can be directed to me at

Student Housing Unit 13/1
c/ Edith Cowan University
Mt. Lawley 6050 WA
(Tel. No. 370-6380)

I (the participant) have read the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising I can withdraw anytime.

I agree that the research data gathered for this study may be published provided I am not identifiable.

____

Participant *Date*

____

Investigator *Date*

Appendix C Interview with participants

Individual:

Would you mind describing your typical mathematics session?
- -lesson presentation
- -management

What would you like to change in what you normally do in your mathematics sessions?

What do you foresee as constraints in implementing your desired changes?
- -personal constraints
- -classroom constraints
- -institutional (school/system) constraints
- -cultural constraints

Any possibilities of implementing the change? How?

Group:

How are things going in your teaching of mathematics?

What worked well? What didn't work? Why ?

Would you like to make some changes in what you do now? What are these?

How can these be implemented?

Appendix D Interview for beliefs and practices

Individual

What do you have to say about mathematics? mathematics teaching? mathematics learning?

Why do we teach mathematics? What do you think is the most important reason for learning mathematics?

How do you compare mathematics with other subject areas?

What do you think students should do in order to learn mathematics?

What is the usual environment in your mathematics class? What are the students doing most of the time?

What do you think most students have in mind about their mathematics teachers?

Group

What do you think is the nature of mathematics?

How would a person learn mathematics? what is your description of a person who likes mathematics? who is good at mathematics?

What do think is the role of a mathematics teacher? a student in a mathematics class?

Appendix E Sample of a portrayal of a lesson

Teacher: XXXX
Year: 10
Number of students: 7 boys; 12 girls
Time: 11: 10-12:10

Portrayal of the lesson:

The class started by announcing some notices such as school activities and food on the canteen. Test papers were returned.

A problem was posed on what does it mean to be paid " two and a half". A student answered and this was elaborated by the teacher. Then worksheets were distributed and students were told to answer it in a blue book for 5 minutes. She then moved around, so with the preservice teacher, to monitor and help students. Now a solution to item 1(a) was discussed through a series of questions and students using calculators. The solution on the board was like this:

works 37 h @ \$4.80
      5 h @ (\$4.80 x 1.5) = \$7.20 / h
37 x \$4.80 = \$ 177.60
 5 x \$7.20 = \$ 36.00

Total \$ 213.60

The discussion proceeded to (b) and (c) by setting out a table.

Time	
6 h	6 x \$ 5.80 =
9 h	9 x \$ 5.80 = 2 x \$ 8.70 =
11 h	7 x \$ 5.80 = 2 x \$ 8.70 = 2 x \$ 11.60 =

A student was asked to fill up the above table while the rest were asked to work on (d) , and then one of them showed the answer to (d).

Students continued answering the worksheets, then the answers to 2 (ai-aii) were discussed. The answers to iii and iv was shown on the board by another student.

There was constant monitoring of students' work by the teacher and the preservice teacher while students were answering the worksheets. A certain student was given much attention during the period, either by helping her in answering the worksheet or commenting on her behavior.

Appendix F Codes used

School type

P	PASMEP school
NP	Non-PASMEP school

Teacher position

T1	Teacher 1
T2	Teacher 2
T3	Teacher 3
MT	Master teacher

Year level of secondary school

Y1	First year
Y2	Second year
Y3	Third year
Y4	Fourth year
Co	Combination class

Number of years of teaching experience

+0	0-5 years
+5	6-10
+10	11-15
+15	16-20
+20	21-25
+25	26-30
+30	31-35

Interview

III	Initial individual interview
IGI	Initial group interview
FII	Final individual interview
FGI	Final group interview

Others

SY	School year
NS	Not specified
NA	No answer

Appendix G Non-PASMEP teacher questionnaire

A-Professional development needs

Name:

School:

Position:

Year level of mathematics you are teaching:

Number of years experience in teaching mathematics:

About Professional Development Needs

1. Is there anything you would like to change in the way you teach mathematics?
   If yes, what would this be?

2. Would you be willing to participate in a professional development program?
   If yes, explain your reasons for participating in such a program.

3. There are other ways of teaching mathematics instead of using, say blackboard and chalk. What other strategies would you like to incorporate in your teaching and you want to be more skilled of?

B-Professional development needs

Name:

School:

About the mathematics teachers in your school

1. What professional development do you think is necessary to enhance your teachers' professional growth?

2. What forms of professional development for mathematics teachers have occurred in your school? How have the teachers changed as a result of this professional development?

3. What professional development activities were you involved in since your return to the Philippines? Please elaborate based on its success/failure, objectives, and so on.

4. Have you been involved in an action research project? Please give details.

C-Professional development needs

Name:

School:

Names of potential participants in

First year:

Second year:

Third year:

Fourth year:

What professional development activities have occurred in your department during the last two years?

What changes have occurred in your department and what other changes would you like to occur?

How would you imagine the way your mathematics teachers may be teaching a few years from now (say 3 years from now)?

Appendix J Sample of letter to the principal

17 July, 1995

Dear ____________________

I am a staff member of the Mathematics Education Group of the University of the Philippines Institute for Science and Mathematics Education Development (UPISMED). At present, I am on study leave pursuing a PhD in Mathematics Education degree at Edith Cowan University in Perth, Western Australia.

As a requirement for this degree, I will be doing a research project entitled *Evaluating a model for school-based professional development of secondary mathematics teachers in the Philippines.* The purpose of this study is to develop, trial, evaluate and document a school-based professional development model for secondary mathematics teachers.

In order for me to do this, I need to send questionnaires to schools with mathematics PASMEP fellows. Then one of these schools will be chosen as the participating school based on the results of the questionnaires and its accessibility to ISMED. If ever your school will be chosen, I will be working with your mathematics department head, PASMEP fellow and four teachers in undertaking an action research program from July 1995 to February 1996, with time allocated to this depending on our needs and the time they could spare.

This study is expected to benefit teachers in learning new ideas and enhancing their understanding of the teaching of mathematics, gain knowledge of professional development and leadership, as well as a chance for them to work with colleagues.

In this regard, may I request the PASMEP fellow to administer the questionnaires for me. Attached is the permission I got from the Department of Education, Culture and Sports for the conduct of this research project.

Your action on this matter is highly appreciated.

Very truly yours,

Florenda L. Gallos

Appendix K Approval from DECS director

Republic of the Philippines
DEPARTMENT OF EDUCATION, CULTURE AND SPORTS
BUREAU OF SECONDARY EDUCATION
3rd floor, Bonifacio Bldg.
U.L. Complex, Meralco Avenue
Pasig, Metro Manila

June 28, 1995

Ms. Florenda L. Gallos
Edith Cowan University
Perth Western Australia
Mounth Lawley Campus
2 Bradford Street, Mount Lawley
Western Australia 6050

Dear Ms. Gallos:

This is in connection with your request to conduct your research project entitled Evaluating a model for school-based professional development of secondary mathematics teachers in the Philippines.

In this connection, please be informed that this Office has no objection on your request to conduct your research project.

Very truly yours,

AVELINA T. LLAGAS
Director

Appendix L Letter to PASMEP teachers

17 July, 1995

____
____
____
____

Dear ____________________

Kumusta ka na? I assumed that like most PASMEP fellows, life has been so busy since then, sharing whatever knowledge and skills we have for our fellow mathematics teachers. Hope this commitment will continue and multiply (exponentially ?!).

As for me, I'm a student again at Edith Cowan University in Perth, the place where we had good memories. As a requirement for my degree, I will be doing a research project entitled *Evaluating a model for school-based professional development of secondary mathematics teachers in the Philippines*. The purpose of this study is to develop, trial, evaluate and document a school-based professional development model for secondary mathematics teachers.

In order for me to do this, I need to send questionnaires to schools with mathematics PASMEP fellows. Then one of these schools will be chosen as the participating school based on the results of the questionnaires and its accessibility to ISMED. For the chosen school, I will be working with the mathematics department head, PASMEP fellow and four teachers in undertaking an action research program from July 1995 to February 1996, with time allocated to this depending on our needs and the time they could spare.

In this regard, may I request you to administer the questionnaires to the following persons:

your department head
four mathematics teachers in your school (1 teacher for every year level)
four mathematics teachers in your nearby school (1 teacher for every year level but not necessarily from the same school)
and you (if you are the department head, please answer 2 questionnaires.)

Please send back the questionnaires using the envelope provided.

Thank you very much. I'm looking forward to work with you again in the near future.

All the best,

Appendix M   Sample diary: meetings and situations

DIARY
Meetings and Situations

Date: Nov. 7, 1995

Present: (Name of participants)

Please make comments about the following:

Your role and contributions:

clarifying the needs, problems and feelings of teachers. suggest alternative action/solution to arising problems

Your feelings about:

. your interactions with the group

Happy because I can see the positive change in them and I can feel that they are beginning to commit themselves to the job - improving mathematics instruction

. how the project is progressing

It is beginning to realize its goals.

Appendix N Sample diary: classroom activity

DIARY
Classroom Activity

Date: Oct 4, 1996

Year and Section: III - Mangga.

Number of students: 58

Topic: Factoring Quadratic Trinomials of the form ax^2+bx+c, $a=1$

About the activity:

Title: Activity 8.6 A. PASMEP Teaching Math III pp 178

Short description:

The students were given algebra tiles in w/c they were ask to find form a square or rectangle and give the dimensions

Result:

The students were able to get the dimensions, at least 3 of them. when they were dealing with negative tiles they need the guidance of the teacher. the concept of zero in the algebra tiles were confusing to them, but once the understood they were able to form on their own.
It also took a little longer than it was supposed.

Suggestions:

The students should be made aware of the use of tiles at a lower. yea level. Particularly on the second year.
The equations should not exceed the no. of tiles for each variables.

Any other comments:

Stress that in using algebra tiles; always use the tiles having the same variables.

Appendix O Sample of researcher's diary

Teacher :
Date/time : 2 October, 1995/2:40-3:20
Year/section : IV/Rizal
No. of students : 63 students

About the activity:

Portrayal:

Students were arranged to work in groups. Each group were given manila paper where there is a drawing of a Cartesian plane and an index card where the equations of the exponential functions and the questions about he activity are written. When they finished, each group posted their work on the board. Then a representative from each group discussed the results of the activity.

Results:

All the groups were able to show the graphs of the exponential functions assigned to them correctly and attractively (using different colors of chalk to identify one from the other). Representative from each group looked confident in discussing the results.

Suggestions:

. In asking a group to graph the equations, involvement of everyone could be maximized if each member be assigned (by them) an x-value for them to find the y-value and plot this on the Cartesian plane.
. Since there were two groups who did the same graphs, the other group could just be asked to give additional information about what had been discussed by the first group.
.Follow-up questions on the student's answer about reflection may be given (say, why is it so? or asking them to verify his answer).

Other comments:

Appendix P Approval from the division superintendent

1st Indorsement
DIVISION OF (Place)
(Address), July 24, 1995

Respectfully referred to the Officer In Charge, (Name of school) High School, (Address), inviting attention to the attached letter dated 20 July 1995 of Ms. Florenda L. Gallos of UP Institute for Science and Mathematics Department, pertinent to her request to undertake a research project in that school, for reasons stated thereon, for appropriate action.

This Office interposes no objection to the activity sought provided no unnecessary interruptions of classroom activities will be involved.

(Signature)
Schools Division Superintendent

03/
ard

Appendix Q Approval from the officer-in-charge

Division of
District of (Name of Place)

Mrs. (Name of officer-in-charge) Date July 31, 1995
District Supervisor

Dear Mrs. F. Gallos,

You are welcome to (Name of school) NHS. Miss A. (Name of head of school) will see to your needs.

Good luck!

Yours,
(Signature)

Appendix R Teacher's consent form for the main study

To the participants:

I, Florenda L. Gallos, a PhD in Mathematics Education student of Edith Cowan University in Perth, Western Australia, will be doing a research project on professional development of mathematics teachers.

The purpose of this study is to develop, trial, evaluate and document a school-based professional development model for secondary mathematics teachers in the Philippines.

In order for me to do this, I need to work with you in undertaking an action research program. Thus, at some time, I will be talking with you or your group, and will be interviewing you and observing some of your classes. Some of our activities will be audiotaped, videotaped and pictures be taken. I plan to work with you from July 1995 to February 1996 with time allocated to this depending on our needs.

This study is expected to benefit you in learning new ideas and enhancing your understanding of the teaching of mathematics, as well as a chance to work with colleagues, and gain knowledge on professional development and leadership.

Any questions concerning the project entitled **Evaluating a model for school-based professional development of secondary mathematics teachers in the Philippines** can be directed to me at the

University of the Philippines
Institute for Science and Mathematics Education Development
Diliman, Quezon City 1101

I (the participant) have read the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising I can withdraw anytime.

I agree that the research data gathered for this study may be published provided I am not identifiable.

Participant *Date*

Investigator *Date*

Appendix S Sample lesson plan

SEPTEMBER 8, 1998
TUESDAY

I. OBJECTIVE

Perform addition and subtraction of decimals.

II. SUBJECT MATTER

1. TOPIC: Addition and Subtraction of decimals
2. REFERENCE: Integrated Math by Sotto pp. 138-157
3. MATERIALS: chart, chalk & blackboard

III. LEARNING STRATEGIES

1. Daily Routine
   1. Checking of assignment on rounding decimals
   2. Review on addition and subtraction of fractions
2. Lesson Proper
   1. Motivation

      If you have ₱10, can you buy a ballpen for ₱3.65 and a notebook for ₱6.95?
   2. Presentation of the lesson

EXAMPLES

(1) $₱3.65 = 3 + \frac{65}{100}$

$₱6.95 = 6 + \frac{95}{100}$

$= 3 + \frac{65}{100} + 6 + \frac{95}{100}$

$= 3 + 6 + \left(\frac{65 + 95}{100}\right)$

$= 9 + \frac{160}{100}$

$= 10 + \frac{60}{100}$ or $10\frac{6}{10}$ or $10\frac{3}{5} = 10.60$

(2) $.3 + .27 + .31 = \frac{3}{10} + \frac{27}{100} + \frac{31}{100}$

$= \frac{30}{100} + \frac{27}{100} + \frac{31}{100}$

$= \frac{88}{100} = .88$

ANOTHER EXAMPLES

1. .30 + .27 + .31 = .88
2. 3.65 + 6.95 = 10.60
3. 37.42 + 18.75 = 56.27
4. ₱10.50 − 5.50 = ₱5.00
5. 1,060.00 − 60.00 = 1,000.00

GUIDE QUESTIONS:

1. What process are you going to use?
2. Do you remember how to add rational numbers in fractional form?
3. How will you add and subtract decimals?
4. What is the difference between addition and subtraction of whole number and a decimal? Can you formulate the rule?

3. GENERALIZATION

* To add decimal numbers, arranged the decimals in one column, then add the numbers.
* To subtract decimal numbers, align the decimal point and proceed as for whole numbers.

4. APPLICATION

Give the sum and difference

1. 23.2 + 48.7
2. 39.5 − 19.8
3. 5.77 − 2.57
4. 0.463 − 0.734
5. 3.59 + 3.21 − 7.02

5. EVALUATION

Solve the ff. problems.

1. Mang Joseph is working on 3 rice plots which are 1.53 ha, .85 ha, and 2.75 ha in size.
   1. What is the total amount of land that Mang Joseph tills?
   2. What is the difference in area between the smallest piece and the biggest piece he tills?

IV. ASSIGNMENT

Perform the indicated operations.

1. 8.7 − 5.3
2. 3.75 + 7.5
3. 10.001 + 3
4. 12.12 + 12 − 12
5. 49.7 + 70 − .95

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