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Intervention Program on the Use of Practical Work as a Teaching Strategy in Elementary School Mathematics: Its Effects on the Teachers' Instructional Skills and Mathematical Ability

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This paper examines the extent to which an intervention program on the use of practical work affected the following two variables: instructional techniques and mathematical ability. An attempt was made to correlate these two variables with age, educational attainment, and teaching experience to determine if there exists a relationship with and without the effect of the intervention. Differences and relationships between these two variables before and after the intervention were significant. However, these two variables were not correlated with age, educational attainment and teaching experience before and after the intervention. Generally, the results and discussion in this paper may serve as a catalyst from which necessary remediation and modification of school and in-service programs could emanate.

Key Words: intervention program, practical work, instructional skills, mathematical ability intervention progra

An excerpt in the NCTM"s overview of principles and standards for school mathematics states that mathematical competence is important because it opens doors to a productive future, whilst lack of it closes those doors. In this respect, teachers, being the primary agent for change are encouraged to continuously update and enhance their knowledge and skills in mathematics. It is because, firstly, it is believed that teachers affect a large number of the student population (Barros & Elia, 1995). Thus, it is important that mathematics teachers are well prepared in teaching mathematics in order that students are better prepared to learn mathematics as well as to develop positive dispositions toward mathematics. Secondly, it is increasingly evident that the teachers' initial preparation is insufficient (Gallagher, 1991; Kahle, 1999; Krasilchik, 1995) and is characterized by lack of correspondence between theory and practice (Caluage, 1995 & Bernardo, 1998). It is believed that mathematics education majors have not been exposed to enough alternative teaching methods to be capable of teaching mathematics with emphasis on meaning (Ball & Wilson, 1990). Thirdly, more often than not, teachers being influenced by how they were taught during their student life tend to replicate the method to their students (Barras & Elia, 1995; Hewson & Hewson, 1988). This is one of the reasons why to date mathematics is still widely criticized for its emphasis on memorization and algorithm. In addition, it can be observed that classroom atmosphere is continually characterized by the traditional mode of telling and showing where teachers are inclined to tell and show students how to perform a step-by-step procedure for solving a mathematical problem instead of teaching mathematics as a process or as a way of thinking (Barras & Elia, 1995) by creating activities that help learners construct understanding of the concept. Other characteristics include chorus recitation, contest-type approaches where

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learners are forced hurry up to finish an activity without giving them enough time to think carefully and reflect on their answers, teachers poor questioning technique that often hinders the progress of higher order thinking skills of learners, among others. As such, the urgency of improving the quality of mathematics teaching requires an end to this laissez-faire approach. There is an urgent need to bring reform in education. Current reforms in mathematics education include providing teachers with training programs which would aim to enhance both teachers' content knowledge and teaching practices. In a study conducted by Gunstone and White (n.d.), results indicate that improved teacher content knowledge helps expand their range of teaching practices. They added that if teachers' knowledge is poor then his/her classroom practice is limited to lectures taken directly from texts and demonstration of solutions of standard quantitative problems.

Quite interestingly, there has been an increasing amount of evidence that shows the impact of training programs upon both practicing and prospective teachers. In the study conducted by Furner (2001), results indicated that a curriculum course has a significant impact on the pre-service teachers' attitude to and belief in mathematics. Another study conducted by Gibson, Brewer, Magnier, McDonald, and Van Strat (1999) showed that a mathematics course taught using a constructivist approach had helped improve pre-service education students' beliefs towards mathematics and enhanced their mathematical ability.

Inspired by the findings of the aforementioned studies and due to scarcity of such studies in the Philippines, the researcher considered conducting this study to examine the extent to which an intervention program on the use of practical work affected the two variables: teachers' instructional techniques and mathematical ability. The researcher also attempted to correlate these two variables with teachers' age, educational attainment, and teaching experience to determine if there exists a relationship with and without the effect of the intervention.

Method

Participants

The subjects were the 32 teachers of grades 5 and 6 mathematics from a division of city schools in Manila, Philippines who participated in the professional development program conducted by the University of the Philippines National Institute for Science and Mathematics Education Development (UP NISMED). These teachers represented seven public schools in that division. Table 1 shows the distribution of the teachers by age, educational attainment and teaching experience.

Instrument

There were three instruments used in this study. The first was a 20-item achievement test aimed to measure teachers' mathematical ability before and after the intervention program. The items were multiple choice, capstone problems that required the teachers to synthesize and integrate concepts and calculation techniques, and open-ended questions where the teachers were asked to validate their conjectures, make generalizations, and other tasks. The UP NISMED trainers of whom the author was a member developed the test. Aside from having been content-validated during the test-item deliberation within the group of trainers, it has been pre-tested by a set of teachers in the field and has been revised accordingly.

The second instrument was a classroom observation checklist designed to measure the teachers' instructional techniques. It consisted of 20 statements that described standards-based teaching practices as modeled several times by the trainers during the intervention program. At the end of

Table 1. *Distribution of the Teachers by Age, Educational Attainment, and Teaching Experience*

29 and below	30-34 years	35-39 years	40-44 years	45-49 years	50 and above	TOTAL
2	3	3	2	7	15	32
BD	MU	MD	DU			TOTAL
16	10	5	1			32
No experience	1-4 years	5-9 years	10-14 years	15-19 years	20 and above	TOTAL
1	10	2	3	5	11	32

Note. BD = Bachelor's Degree; MU = With Master's units; MD = Master's Degree; DU = With Doctoral units.

every statement was a scale of 1 through 5, with 5 being the highest, served as the basis for scoring. Hence, each item for each respondent was scored on a five-point continuum. Then, these item scores were summed up, with 100 points (5 times 20 items) being the highest possible score and 20 points (1 times 20 items) being the lowest possible score. Again, the UPNISMED trainers developed this instrument. It was content-validated in a discussion with school principals and supervisors and other school personnel who helped improve vague and misleading items. Presently, the instrument is being used as a checklist instrument by some school principals and supervisors during classroom observations.

Meanwhile, the third instrument was a focus group discussion guide consisting of two major questions with each having 7 and 9 sub-questions, respectively. These questions delved into detailed information pertaining to the teachers' teaching practices in mathematics before and after they participated in the intervention program.

Procedure

The achievement test was administered to the teachers twice: at the beginning and at the end of the intervention program. The data were analyzed to find if there were significant differences in the teachers' mathematical ability before and after the intervention. The data were also used to find if there were significant relationships between teachers' mathematical ability and their other personal characteristics (i.e., age, educational attainment and teaching experience). Meanwhile, since this study was conducted several months after the six-month post-intervention activity, the researcher sought the help of the mathematics supervisor of that division. Using the classroom observation checklist instrument, the supervisor was asked to rate the way the teachers carried out a mathematics lesson using classroom observation records and other teacher performance-related records she acquired prior to the teachers' participation in the intervention program. As the schools in that division are all public schools, the supervisor has been using a classroom observation checklist prescribed by the Department of Education. Therefore, to accomplish this task the supervisor had to transfer the teachers' scores from the previous classroom observation records to the classroom observation checklist instrument. Since the division mathematics supervisor's main function is to observe and supervise teachers in the classroom, this task was done quite easily. Two months after the supervisor finished the task, she was asked again to rate the same set of teachers, but this time to use the classroom observation checklist instrument in her classroom observations with these teachers. This is how the teachers' teaching practices in mathematics before and after the intervention were assessed.

To gather additional information, the researcher conducted a focus group discussion (FGD) with these teachers. These teachers were divided into four groups for the planned FGD's four sessions. The first group served as the try-out group during the first session. To ensure complete attendance from the teachers, the FGD was designed so as not to disrupt classes and any school activities the teachers may have, and it was conducted every other week which usually ran for 45 to 60 minutes per session, to give the researcher time to make some adjustments and revisions for further improvements in the conduct of succeeding sessions. The whole process was videotaped to give the researcher a chance to go over with the teachers' views, arguments, as well as physical expressions that may help in the qualitative analysis for the study. The FGD together with classroom observations, informal interviews with the teachers, and written lesson plans provided the qualitative data for the study.

The Intervention Program and Post-Intervention Activity

Elementary mathematics education should not only focus on the development of mathematical concepts and skills but upon the learners' thinking as well. Taking this into account,

Table 2. *Analysis of the Paired Comparison (or Dependent) t-test Performed on the Teachers' Teaching Practices and Their Knowledge of Mathematical concepts Before and After the Intervention Program (N=32)*

	Before		After		
	Mean	SD	Mean	SD	
Teachers' Teaching Practices (Perfect Score = 100 pts.)	59.91	6.40	83.21	7.69	-19.00*
Teachers' Knowledge (Perfect Score = 20 pts.)	7.91	4.67	16.74	3.31	-13.45*

*p < .05, two-tailed.

Table 3. *McNemar's Chi-square test of Change in Knowledge of the Concept Measured per Item of the Pretest/ Posttest (N=32)*

Item No. (Mathematical Content)	A(+,+)	B(+,-)	C(-,+)	D(-,-)	Chi sqr
1 (Ratio and Proportion)	13	2	13	4	6.67*
2 (Interior angles of a triangle in Geometry)	13	0	18	1	16.06*
3 (Numbers and Operations)	2	0	28	2	26.04*
4 (Area Measurement)	6	0	19	7	17.05*
5 (Division of Fraction)	11	2	13	6	6.67*
6 (Numbers and Operations)	12	1	17	2	12.50*
7 (Division of Fraction)	18	4	10	0	1.79
8 (Maps and Scales)	6	4	13	9	3.76
9 (Percent)	23	1	7	1	3.12
10 (Spatial figures in Geometry)	3	0	27	2	25.04*
11 (Applying four fundamental operations)	10	3	10	9	2.77
12 (Meter Reading)	12	3	11	6	3.50
13 (Bar Graphs in Data Handling)	13	7	7	5	0.07
14 (Circle Graph in Data Handling)	0	0	18	14	16.06*
15 (Volume Measurement)	9	0	16	7	14.06*
16 (Spatial figures in Geometry)	17	1	13	1	8.64*
17 (Area Conservation and Geometry)	14	0	16	2	14.06*
18 (Meter Reading)	3	0	21	8	19.05*
19 (Circumference of a Circle)	7	1	19	5	14.45*
20 (Area of a Circle)	7	2	17	6	10.32*

*$p < .05$, two-tailed.

the intervention program has two major objectives: to upgrade the teachers' mathematical ability and to enhance their thinking skills and processes.

In every session, lessons that integrate mastery of the curriculum content and teaching strategies described by research as standards-based teaching were modeled. The mathematical contents covered in the training program adopted the topics (as listed in Table 3) in the Elementary Learning Competencies (ELC) in the Philippines, while the strategy-related topics included lesson planning, assessment, thinking skills, understanding practical work, investigation, problem solving, outdoor mathematics and games in mathematics.

In the intervention program, a session consisted of two parts: a demonstration of a 40-minute exemplar lesson by a trainer and a discussion in the activity called "Extending/ Connecting Ideas". The former aimed to demonstrate to the teachers how a lesson in mathematics should be conducted using standards-based teaching, while the latter was meant to enhance the teachers' mastery of the curriculum content.

On the first day of the intervention program, the teachers were informed that as part of the program requirement, they would each conduct a demonstration teaching lesson with their peers. Thus, towards the end of the program, the session on microteaching was held. In this session, the teachers were asked to demonstrate a lesson focusing on the "rule formation or concept development" stage only due to time constraints. Its purpose is to provide an opportunity for the teachers to review, practice and enhance the teaching practices and techniques introduced and modeled on many occasions during the intervention program. The critiquing that followed each demonstration lesson proved to be very enlightening because it gave the teachers the chance to clarify strategy- and content-related questions. More importantly, they learned from each other's strengths and weaknesses.

The specific objectives of the intervention program were as follows:

1. To discuss the importance of developing the learners' mathematical concepts;
2. To use practical work effectively in teaching mathematics;
3. To create opportunities for developing higher order thinking;

4. To upgrade mastery of the curriculum content.

After the intervention program, the trainers monitored and observed the mathematics classes handled by the trained teachers in order to determine how knowledge and skills acquired during the intervention program were being adopted in the classroom. After every classroom observation, the trainers conducted post-conference meeting with the teacher concerned during which strengths and areas for improvements were clarified. The intervention program was a 10-day intensive course that ran for 6 hours a day consisting of two 1.5-hour sessions in the morning and another two in the afternoon, while the post-intervention activity ran for about six months at an average of 4 to 6 classes per week.

Data Analysis

The following were the statistical tools used: (1) Paired Comparison (or Dependent) *t*-test, to find out if there were significant differences in the two variables: teachers' instructional techniques and mathematical ability before and after the intervention; (2) McNemar's Chi-square test, to find the significance of item gains in the achievement test; (3) Pearson product-moment correlation which was used to determine the direction and degree of relationship between: (a) the two variables before and after the intervention; (b) teachers' other personal characteristics (i.e., age, educational attainment, and teaching experience) before and after the intervention. The statistical significance was determined at a .05 level of confidence.

Findings

1. Exploring the effect of the intervention program with an emphasis on practical work as a teaching strategy on the teachers' instructional skills and mathematical ability

In this study it was hypothesized that the intervention program had a significant effect on the teachers' instructional techniques and mathematical ability. To test this hypothesis, the teachers' scores before and after the intervention were compared using a paired *t*-test. Results presented in Table 2 showed a significant difference between the teachers' instructional techniques before and after the intervention (t = -19.00, p<.05). In fact, before the intervention their mean score was 59.91, which improved to 83.21 after the training. Likewise, results in the teachers' mathematical ability showed that there was a significant difference (t = -13.45, p<.05) between the mean score of 7.91 before the intervention and the mean score of 16.74 after the intervention.

Meanwhile, Table 3 shows the McNemar's table of symmetry for significance of item gains in the achievement test. All the items showed positive gains, although there were six items (items 7, 8, 9, 11, 12, and13) that did not show significant change. These six items dealt with topics such as division of fraction, maps and scales, percent, applying the four fundamental operations, meter reading, and bar graphs, respectively. Of the 14 items with significant positive change, 11 or 79% had 50% or more teachers who did not give correct answers in the pretest answering them correctly in the post-test. Items 3, 10, 18 and 4 showed the highest significant change with 88%, 84%, 66% and 59%, respectively, of those who were not able to answer correctly in the pretest but did well in the post-test. Item 13 showed the lowest gain [X^2(1, N=29) = 0.07, p>.05] and together with item 11 [X^2(1, N=29) = 2.77, p>.05] showed that 38% of the teachers had not mastered the concepts being measured (i.e., bar graph and applying the four fundamental operations) even after the intervention. Apparently, the teachers changed much on items dealing with numbers and operations, spatial figures, meter reading, and area measurements. In the achievement test, the first two concepts mentioned have a joint characteristic of visualization, while the last two concepts have a joint characteristic of calculation or

Table 4. *Correlation of Teachers' Teaching Practices, Knowledge of Mathematical Concepts, Age, Educational Attainment and Teaching Experience (N=32)*

	TBAI	Pretest	Posttest	Age	EdAt	TExpr
TPBI	.51*	-.04	--	--	--	--
Pretest	--	--	.56*	--	--	--
TPAI	--	--	.26	-.20	.18	.15
Posttest	--	--	--	-.30	-.07	.26

Note. TPBI = teaching practices before the intervention; TPAI = teaching practices after the intervention; EdAt = Educational Attainment; TExpr = teaching experience.
*p < .05, two-tailed.

applying the right algorithm.

2. Exploring the relationship between the teachers' instructional skills and mathematical ability before and after their exposure to the intervention program on the use of practical work

This study also hypothesized that there was a significant relationship between teachers' instructional techniques and their mathematical ability before and after they were exposed to the intervention program on the use of practical work. To establish evidence for the rejection or acceptance of this hypothesis, the Pearson product-moment correlation was used.

Table 4 shows that there was a significant relationship (r=.51, p<.01) between the teachers' instructional techniques before and after the intervention program. This finding held true also for the teachers' mathematical ability (r=.56, p<.01). This means that the teachers who perform better before the intervention program tend to perform better even after the intervention program. However, no significant relationship was found between the teachers' instructional techniques and their mathematical ability before (r= -.04, p>.05) and after (r=.26, p>.05) the intervention program.

3. Relationship between teachers' age, educational attainment and teaching experience with their teaching techniques and mathematical ability

Still on Table 4, it can be gleaned that there were no significant relationships not only between educational attainment (r=.18 and -.07, respectively) and either of the two variables: instructional techniques and mathematical ability, but also between teaching experience (r=.15 and .26, respectively) and again either of the two variables. Nevertheless, although no significant relationship was found between the teachers' age and the variables instructional techniques (r=-.20) and mathematical ability (r=-.30), the negative and slightly higher correlation is worth mentioning.

Discussion

Participants' profile

Of the total number of teachers, only 12 or about 34% were males. The ages range from 26 to 58 years. Although 47% of the teachers are of ages ranging from 50 and above while 22% comprise the age range of 45-49, the average age of all the teachers was 45 with a standard deviation of 8.91.

Fifty percent of the teachers have a bachelor's degree only. While 31% have achieved some units in master's programs, only 16% manage to get a master's degree. One of the teachers had some units at the Ph. D. level.

As for the teachers' teaching experience, referred to in this paper as the number of years these teachers have taught mathematics, all but one of the teachers have experience in teaching mathematics at an average of five 40-minute class periods everyday from Monday to Friday. The category "20 and above" composes the highest percentage constituting 34% of the teachers. This is not surprising because the age range of "50 and above" also garners the highest percentage of the teachers, thus confirming the assumption that teaching experience is a function of age. Contrary to this assumption, however, the age range of "29 and below" or 6%, seems to be disproportionate to teaching experience "1 to 4 years" which has 31%. The great discrepancy could be associated to the following possibilities: that most of the teachers belonging to "1 to 4 years" category are not initially meant to teach mathematics as they enter the teaching profession, or it could be that most of them might have preferred teaching subjects other than mathematics during the early stage of their teaching career. In the Philippines, only in the 1990s had specialization in the course leading to teaching in the elementary schools been offered (Miguel, 1992). This gave the teachers an option to teach their subjects of preference.

The Intervention Program on Practical Work: Its Effect on the Teachers' Instructional Skills and Mathematical Ability

A mean score of 59.91 indicates that the teachers possessed some good instructional techniques in teaching mathematics even before they participated in the intervention program. During the focus group discussion, it was determined that a few of these teachers were already using, to some extent, practical work as a teaching strategy. It seemed that they were not aware of the name practical work until they participated in the intervention program. Nevertheless, it was sensed that before the intervention, a considerable number of teachers had rarely provided an activity that would require the pupils to perform tasks that promote an atmosphere of exploration. And since they had limited knowledge of open-ended problem solving that promotes complex, higher-order thinking, as indicated in the qualitative analysis of their answers in the pretest, there was no attempt to bring this in their teachings. However, after the intervention, the teachers' teaching practices had improved a great deal. In an interview with the mathematics supervisor, it was mentioned that because of the intervention program, the teachers had learned to better prepare a mathematics lesson that presents instructional steps logically, following the principle of "concrete-to-abstract" or the so-called "hands-on and minds-on" learning, thereby all the more promoting the use of practical work considered by research as standard-based teaching strategy.

A qualitative analysis of the teachers' answers in the open-ended questions indicated that before the intervention they seemed not to be familiar with the different heuristics in solving mathematical problems especially of those of non-routine ones. They got stuck on problems that require different ways in arriving at an answer, or sometimes they wrongly answer an item due to their unsystematic method of performing it. An example is the item "Write a number expression that tells the total number of circles in the figure", which appeared on both pre- and post- tests. At the start of the intervention, most teachers just gave the total number of circles as the answer without providing the required number sentence. They did it by counting the circles one by one, a manifestation of being deeply entrenched in primitive counting, thus the reason why only 6% of the teachers got it right because some circles had been counted twice. At the end of the intervention, the teachers employed the skill of identifying patterns which is a more effective and systematic way of getting the number of circles in a figure, hence the percentage (94%) of teachers answering this item correctly had increased dramatically.

The result of McNemar chi square test shows that while the teachers performed fairly well in data handling that involves constructing a circle graph, they performed poorest in interpreting a bar graph. This could be due to the fact that in the elementary mathematics curriculum in the Philippines, bar graphs are tackled in grades 3 and 4, while circle graphs are in grade 6, or sometimes an extension lesson in grade 5. During the focus group discussion, the idea that teachers seldom have spare time to study subjects other than the ones they are required to teach in the grade level for which they are assigned to handle had transpired. Due to a hectic schedule brought about by too many subjects to teach and too many school-related activities to comply with, their time is just enough to prepare and study for their immediate needs. Consequently, teachers have limited knowledge on topics beyond their teaching assignments, something quite contrary to what is expected of them. Being teachers, they should be familiar with the mathematics content being taught across all grade levels.

Relationship between the Teachers' Instructional skills and Mathematical Ability before and after Their Exposure to the Intervention Program on the Use of Practical Work

The finding that there was no significant relationship between the variables: teachers' instructional skills and mathematical ability before the intervention program implies that regardless of whether or not a teacher has good teaching practice, he/she did not fare well in the test. It can be recalled that before the intervention the teachers' mathematical ability mean score is only about 40%, while their instructional techniques mean score is a little higher at about 60%. This finding may have sprouted from the fact that the test given to the teachers consisted mostly of open-ended questions and some non-routine problems, which are unfamiliar to them, thereby producing a very low level of performance, albeit having quite good instructional techniques. A qualitative analysis of the classroom observations conducted before the intervention shows that most of the teachers limit themselves to the use of worksheets or exercises from textbooks, which really is a problem since up to 95 percent of the questions from these sources are lower-order (factual) questions (Reck, 1990), thus giving them very little opportunity to develop their skills in problem solving and to familiarize themselves with open-ended questions and non-routine problems. Meanwhile, the relationship of the two variables has become moderate although still not significant after the intervention. It can be seen back in Table 2 that the two variables (i.e., instructional techniques and mathematical ability) had increased dramatically. Here, although the Pearson r could not say whether the great improvement in their content knowledge (119%) had caused their teaching practices (22%) to change, but it could be inferred that the former could, to some extent, have influenced the latter. This finding, thus confirms the research findings (Gunstone & White, n.d.) that improved teacher content knowledge may influence teachers' teaching practices in the classroom. Results of the classroom observations show that when teachers, for example, cover topics about which they are very well prepared, they encourage students' questions and discussions. However, when they teach a topic about which they are less well informed, they often discourage active participation by students and rely more on presentations than on students' discussions.

Relationship of the Teachers' age, Educational Attainment and Teaching Experience to Their Instructional Techniques and Mathematical Ability

The finding that there was no significant relationship between the teachers' educational attainment and the variables instructional techniques and mathematical ability may mean that regardless of whether or not the teachers have taken subjects in the master's or Ph. D. level, their performance would be no different. An analysis of the teachers' background showed that teachers who have gone to graduate studies had mostly taken subjects related to public administration, industrial education, among others; and rarely had they enrolled in mathematics-related subjects. This could be the reason why in this group of teachers, educational attainment is not related to their performance. Additionally, teaching experience was found to be of no influence on their performance. It was learned in the focus group discussion that these teachers were given little opportunity for in-service trainings. Most of them did not know what it is like to be in a training program, workshop or seminar in mathematics. While these teachers possessed knowledge and skills they acquired in the pre-service training they participated in, there is no denying that the pre-service training for teachers in the Philippines, as the situation in other countries (Gallagher, 1991; Krasilchik, 1995), poorly prepares teachers for the teaching profession.

The negative and slightly higher (though not significant) correlation between age and the two variables instructional techniques and mathematical ability is particularly striking. This finding may imply that younger teachers are more open-minded to receiving new knowledge, skills and strategies introduced during the intervention than older ones. One possible reason is that since some of the instructional techniques introduced in the intervention program are quite new and are barely being practiced yet especially in their division, some teachers especially the older ones, find these new things irreconcilable with the views they adhered to about mathematics and mathematics teaching for quite sometime already. To them, mathematics was computation and facts, and that learning involves memorizing facts and information. It is quite obvious that these teachers use approaches that are consistent with the beliefs they hold. Again, this confirms the findings in the study of Gunstone and White (n.d.) as mentioned earlier that teachers' ideas and beliefs about teaching and learning are powerful influences on their actual approaches to teaching. In fact, in the focus group discussion with the teachers their skepticism surfaced. They are skeptical about the use of practical work as a teaching strategy not only because this strategy employs the manipulation of concrete objects as a springboard for developing understanding of mathematical concepts but particularly because it involves the manipulation of ideas in the form of problem solving and mathematical investigations. Because of this, they believe that this teaching strategy may require a longer time to carry out a lesson and they are worried that they may not be able to finish their lessons within the allotted time because they are not used to using this teaching strategy in the same way as the students are not used to being taught with this kind of teaching strategy. Lastly, they are skeptical that some of the things being introduced to them in the intervention could not be feasible in the classroom setting in the Philippines considering factors such as: large class size, narrow classrooms, and inadequate materials, among others.

Conclusions and Implications for in-service teacher education

One of the objectives of the study was to determine if an intervention program significantly affects the teachers' instructional skills. In the classroom observations that were conducted after the intervention, most of the teachers were receptive to the instructional techniques modeled during the intervention program. However, a number of these teachers hardly recognized that the hands-on and the minds-on components of practical work are equally important for this strategy to be effective. This implies that these teachers need to have more of a holistic understanding of the nature of practical work. It is thus suggested that follow-up training be conducted to straighten up and strengthen the initial knowledge these teachers have on the use of practical work as a teaching strategy.

The finding that teachers performed relatively well in constructing a circle graph but did poorest in interpreting a bar graph implies that the teachers should be required to review and study not only the topics for which they are prescribed to teach, but also other topics across all grade levels. They should be ale to see that topics in mathematics are closely related or interconnected rather than unconnected. Additionally, this finding implies that future training programs should be designed to enhance the learners' skills of interpretation.

Overall, the statistical test in Table2 and Table 4, the item analysis in Table 3, the qualitative analysis of the teachers' answers in the open ended questions and the result of the focus group discussion and classroom observations indicate that teachers' instructional techniques and mathematical ability could be changed through an in-service program. It is therefore suggested that more effort should be put into conducting in-service programs of this kind in a more widespread manner for the benefit of other teachers and students in the country.

References

Ball, D. L., & Wilson, S. M. (1990). *Knowing the subject and learning to teach it: Examining assumptions about becoming a mathematics teacher*. East Lancing, MI: Michigan State University. (ERIC Document Reproduction Service No. ED 323 207).

Barros, S., & Elia, M. (1995). Physics teachers' attitude: How do they affect the reality of the classroom and models for change? Website: http://www.physics.ohio-state.edu/jossem/ICPE/D2.html .

Bernardo, A. B. (1998, September). The striving and the struggle for teacher development: The contexts, issues, trends, and opportunities in in-service teacher training in the Philippines. In *Ensuring opportunities for the professional development of teachers*. Paper presented at the UNESCO-APEID Seminar, Hiroshima University, Japan.

Caluage, A. C. (1995). A teacher retraining center at the Ateneo de Manila University. In: *Teacher Education: Innovative alternatives for the 21st century*. International Conference in Teacher Education, Chulalongkorn University, Thailand.

Furner, J. (2001). *The effects of a math curriculum course on the beliefs of pre-service teachers regarding the National Council of Teachers of Mathematics' Standards*. Retrieved December 12, 2002 from http://www.k-12prep.math.ttu.edu/journal/pedagogy/furner01/article.pdf.

Gallagher, J. (1991). Prospective and practicing secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education*, *75*(1), 121-133.

Gibson, H., Brewer, L., Magnier, J., McDonald, J., & Van Strat, G. (1999). *The impact of an innovative user-friendly mathematics program on preservice teachers' attitudes towards mathematics*. (ERIC Document Reproduction Service No. ED 430 930).

Gunstone, R., & White, R. (n.d.). *Teachers' attitudes about Physics classroom practice*. Retrieved December 12, 2002 from Ohio University, Institute of Physics Web site: http://www.physics.ohio-state.edu/jossem/ICPE/D1.html

Hewson P. W., & Hewson M. G. (1998). On appropriate conception of teaching science: A view from studies of science learning. *Science Education, 75*(5), 529-540.

Kahle, J. B. (1999). *Teacher professional development: does it make a difference in student learning?* Testimony to the House of Representatives Committee on Science, Washington, D.C.

Krasilchik, M. (1995). The Ecology of Science education: Brazil 1950-90. *International Journal of Science Education, 17*(4) 413-423.

Miguel, M. (1992). Enhancing Learning Achievement in Primary Education in the Philippines. *Proceedings of the UNESCO APEID Seminar, Hiroshima, Japan*.

Mueller, D. (1986). *Measuring social attitudes: A handbook for researchers and practitioners*. New York: Teachers College Press.

Reck, C. (1990). *Successful instructional practices for small schools*. National Parent Information Network. (ERIC Document Reproduction No. ED326352).

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