Preparing More and Better Teachers: The Role of Prospective Teachers' Education in Supporting Mathematics Education Reform: A Case Study

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Introduction

The content of this paper is taken from an ongoing and larger study "Basic Education Support Program (BESP) in Tigrai, Ethiopia". The project has been funded by the Banyan Tree Foundation.

The BESP has two main objectives:
To implement a teacher-training program for the primary second cycle (5th – 8th grade) education and college faculty with the opportunity to enhance their professional knowledge and skills in current methodologies for teaching of Mathematics, Science and English, and to implement a "Training of Trainers" graduate program that will upgrade the knowledge and skills of faculty at Abbyi Addi Teacher Training College.

This piece of work will attempt to address some of the results of the first two years' findings pertaining to first objective. The specific area of interest in this discussion is middle school mathematics education and the effects of an intervention program conducted in the summers of 2000 and 2001. Data collected on attitudes of teachers who participated in the intervention program (Mathematics Methods Course) and the outcome of mid-semester tests from control groups of students and from experimental groups of students (taught by program participant teachers) show promising result. Therefore, the

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paper can be considered as a case study on the effects of the student-centered instructional practices in the overall Ethiopian education system.

The paper is organized in three sections. The first section comprises review of literature which includes pre-service education, in-service education, Mathematics education, and the role of manipulative and hands-on activities in Mathematics education. The second section addresses the methods used in the study, which describes the subjects and instruments. The third section discusses the results of the study and the conclusion.

Literature Review

Teaching mathematics requires knowledge of mathematics, students, teaching, and the opportunities to apply this knowledge in varied settings and situations (Mosenthal et. al. 1992; Shulman 1997).

To attain the goal of developing students' mathematical power, teachers need to know mathematics and how to teach it, which include mathematical and pedagogical knowledge. The foundation for mathematics education is laid during the pre-service education. This period should also prepare prospective teachers to develop their own teaching skills and mathematical knowledge throughout their career. To help students learn better, teachers should continue to develop their teaching skills and mathematical knowledge while they are in-service. They must continue to learn how students learn, analyze issues in mathematics teaching, and use new materials and technology.

Pre-service Education

Three major components dominate the preparation of teachers: the liberal (general) arts and sciences, specialized subject-field education, and professional education (Grow-Maienza 1996). The liberal education provides the general knowledge that combines the arts and sciences and seeks to give the student a broad cultural background. The specialized subject-field consists of a group of courses in a specific subject area, usually known as "major" or "minor" in colleges and universities. Courses designed for professional education are designed to provide the skills and knowledge of teaching. The overwhelming majority of all educators agree that the three components of any teacher education program are important for preparing good teachers.

A new reform movement has been underway to address the problems and other critical issues in teacher preparation programs. Through extensive studies and research findings, many educators are focusing on the need for a strong knowledge base for pre-service teachers (Shulman 1987). Shulman (1987), on the other hand, points out that such a knowledge base in education is not clearly identified and defined. Moreover, he states that there are no specifications on what teachers should know, do or should understand more than what an individual will acquire from his or her efforts. Shulman, further, presents a solid argument regarding the existence and availability of the content, character, and source of knowledge base of teaching. According to him, the potential sources for a knowledge base are numerous, but he categorizes the following as a minimum list for the knowledge base:

- content knowledge
- general pedagogical knowledge
- curriculum knowledge
- pedagogical content knowledge
- knowledge of learners and their characteristics

- knowledge of educational contexts; and
- Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds.

Modern views of knowledge state that "…it is negotiated, distributed, situated, constructed, developmental, and affective" (Murray, 1996, p.10). Therefore, the goal of teacher education must be to prepare prospective teachers "…to reason soundly about their teaching as well as to perform skillfully. Sound reasoning requires both a process of thinking about what they are doing and an adequate base of facts, principles, and experiences from which to reason" (Shulman, 1987, p.13). Teachers must be prepared so that they understand child development, pedagogy, and the structures of subject areas and varied methods of learning assessment (Darling-Hammond and Cobb, 1996).

Stoddart et al. (1993) argue that traditional didactic approaches of instruction are not effective in the development of conceptual understanding. While teachers' understanding of content and pedagogy is strongly influenced by their experience as students, most teachers acquired their content knowledge through the ineffective didactic approaches. This results in the prospective teachers' limited conceptual understanding of the subject matter. Stoddart et al. (1993) infer that teachers who do not have conceptual understanding of the content are not equipped to teach conceptually. They propose that to improve mathematics instruction, a new reform of education that integrates subject matter and pedagogy is needed. For this reason, teacher education programs should be designed to enable and help prospective teachers develop new conceptual perspective through which content –facts, principles, instructional practices- can be personally mandated and negotiated. Shulman (1987) also concludes, "The emphasis on the general relationship between teaching and the scholarly domains… makes clear that the teacher education is the responsibility of the entire university, not the schools or departments of education alone" (p. 20).

In-service Education

In-service education is a further training of teachers that may be additional education that focuses on subject matter, teaching skills, or any other areas that increases teacher effectiveness. In-service education helps teachers to get up-to-date information for their preparations and gain new classroom skills.

Although strong content knowledge is necessary to good teaching, there are many entities that pre-service and continuing teachers need to develop (Even and Torish, 1995; Mosenthal and Ball, 1992; Murray, 1996). Therefore, for in-service teachers that have been teaching for many years, programs that help develop strong content and pedagogy are often offered in the form of workshops and other professional development programs

The first standard, Experiencing Good Mathematics Teaching, suggests that teachers and institutions that prepare teachers need to alter substantially their instructional philosophy from lecture and demonstration to a focus on facilitating students' construction of their own knowledge. To this end, emphasizing discovery teaching/learning, cooperative learning and group discussions would be excellent ways for learners to explore, develop mathematical arguments, and identify connections among mathematical ideas.

The second standard, Knowing Mathematics and School Mathematics, deals with the need for teachers not only master the content and discourse of mathematics but also to prepare for the growth and changes that mathematics is going through in our society. At the minimum, the education of teachers of mathematics should develop mathematical concepts and procedures and the connection between and among them; multiple representations of mathematical concepts and procedures; and ways to reason mathematically, solve problems, and communicate mathematics effectively at different level of formality.

The third standard is Knowing Students as Learners of Mathematics. This standard advises that pre-service and continuing education should provide multiple perspectives on students as learners of mathematics by developing teachers' knowledge of research on how students learn mathematics: the age, ability, interests, and experience influencing student learning as well as continuation of mathematics study by all students.

The fourth standard, Knowing Mathematical Pedagogy, focuses on the need for continuing and pre-service education to develop teachers' knowledge and ability to use and evaluate. Identifying and assessing instructional materials and learning to use these resources is fundamental as it helps in the selection and representation of worthwhile mathematical ideas. Modeling and representation of mathematical ideas are key ingredients to teaching mathematics effectively. The importance of assessment to be part of mathematics teaching is also stressed since teachers learn how students think about mathematics through assessment.

The fifth standard, Developing as a Teacher of Mathematics, addresses the most important aspect of teaching. This standard proposes to provide teachers with opportunities to evaluate their own assumptions of mathematics and how it should be taught; analyzing varied approaches of teaching and learning mathematics for the diverse population; and developing the dispositions toward teaching mathematics. From the experience of teaching and learning, confident teachers of mathematics emerge. The confident teacher exhibits flexibility and comfort with his or her mathematical knowledge.

The last standard is the Teacher's Role in Professional Development. It holds teachers to be responsible for their own professional development and growth in their profession. In doing so, they portray themselves as agents of change and responsible for the improvement of mathematics education.

Mathematics Education

Mathematics education has recently seen a much more accelerated change, among other things, in the way we evaluate and assess its intended outcomes than ever before. Kieran (1994) quotes "Today we know little more than we knew 50 years ago about cause-effect relationships between instructional actions and learning outcomes…" (p.591). Two of the main reasons for the lack of advance in knowledge about curriculum and instruction are the phenomena to be investigated are very complex, and the epistemological basis needed to deal in such complex areas did not exist. There were many attempts to reform teacher education by popular groups, such as the Carnegie Forum on Education and the Economy and the Holmes Group. However, many of the recommendations made were not based on research evidence, but by "…forces better characterized as whimsical as rational" (Wilson, p. 346).

In the last twenty years, mathematics education has become better established as a domain of scientific research. Unlike experimentation with physical sciences, however, it is nearly impossible to replicate educational research in the same manner and under the same condition. Therefore, the new knowledge needs to be legitimized by the process by which the new knowledge was attained (Gravemeijer, 1994).

Kieran (1994) identifies a shift in focus of educational research from learning outcome to learning process, from the learner to the teacher, and from an individual student's learning to the learning process in the social situation in the classroom. Skemp's work on relational understanding coupled with Piaget's constructivist theory may have the greatest contribution in building the notion of learners' conceptual frameworks, which led to the latest reform of mathematics education (Kieran, 1994). One of the centerpieces of the new focus in mathematics education is that learning is viewed as an active and ongoing construction of mathematical knowledge. The learner attains the greater mathematical knowledge by building and modifying his or her current mathematical way of knowing (Cobb, Yankel and Wood, 1992). Mathematical knowing also consists of social and cognitive aspects. In fact, Vygotsky (1978) puts more emphasis on the social interaction and the role of social process in the construction of knowledge.

The NCTM Standards along with the "… emergence of constructivism as an epistemological foundation for mathematics education have fueled enormous energy directed at reform of both teaching and teacher education. Concomitantly, research on teacher education has emphasized meaning and interpretation, resulting in what Stake (1978) calls 'naturalistic generalizations rather than statistical generalizations'" (Cooney, 1994, p. 609). Accordingly, the development of teachers' pedagogical content in mathematics education should be grounded in what we know about how children construct mathematical ideas. One of the main contributions of research on children's learning to teacher education includes providing teachers with the type of knowledge that would allow them to construct viable models of children's learning of mathematics. To this end, Cooney (1994), outlines that the literature on being a mathematics teacher emphasizes on the teacher as a cognizing and reflective agent. He adds as:

> Thinking of the teacher as a cognizing agent, much as we desire them to think of their students, provides an important orientation to our thinking about research on teacher education. It encourages us to consider why teachers behave the way they do, how they make sense of their world, and what meanings they assign to their experiences in teacher education programs" (p.612).

The present study examines Tigrai middle school Mathematics teachers teaching practices and the conditions under which they teach. To provide some insight into the above points and to explore the effect of some American instructional practices on the Tigrai middle school Mathematics teachers and students, four research questions were posed:

- How were the Tigrai prospective middle school Mathematics teachers prepared?
- What major problems did the Tigrai Mathematics teachers face in discharging their duties?
- What were the effects of some of the American teaching practices on the Tigrai middle school Mathematics teachers?
- What were the effects of some of the American teaching practices on the Tigrai middle school Mathematics students' achievement tests?

Method

Subjects

The subjects of this study were the first and second graduating class of the special program at Abbyi Addi Teacher Training College. The college conducts two programs simultaneously. Recent high school graduates are admitted to the college for a two-year diploma program for a certification to teach at the second cycle of primary schools (grades 5 through 8). The special program admits in-service teachers with a one-year teaching certificate, (TTI graduates), who have been teaching at the first cycle primary school (grades 1 through 4). The special students complete a three-semester program in a twelve-month school year and would be teaching at the second cycle primary schools.

Instrumentations

Personal Journals

Each prospective teacher participant was required to write one to two pages in a personal journal for each week's class activities.

End-of-course Evaluation

This is a three-part questionnaire that includes the rating of teachers' familiarity with student-centered teaching practices, the extent in which the course will help them in delivering their mathematics lessons in their classrooms, and some open-ended questions that ask for specific examples of content(s) they will use from the summer activities and their general impressions and suggestions about the course. The summer course instructors' assessment was also used.

Mid-semester Student Performance Test

Finally, the study also evaluated the impact of the intervention program in the classrooms. Much of the materials presented in the summer program were covered by mid-semester in the 5^{th} through 8^{th} Mathematics curricula. Mid-semester exams were prepared based on the curriculum and were administered to some selected participant teachers' classes (experimental group) and control group. These exams were administered by Abbyi Addi Teacher Training College instructors.

Results

Personal Journals

Each prospective teacher participant was required to write one to two pages in a personal journal for each week's class activities. Each journal was due on the following Monday. The journals were to be reflections of the overall activities as well as how the materials were, what they gained and/or not gained from the course presented and used for the given time period. They were particularly asked to address the following questions in the journals.

1) Have you ever used concrete demonstrative materials to teach or learn? Describe briefly.
2) Are any of the teaching/learning methods used similar to what was presented in class? If so, which ones and how?
3) Did you learn some methods in this class that you would use in your own classes? Describe.
4) Did you learn any methods that may not apply for your teaching, but could be modified? How would you modify it (them)? Describe.
5) Did you see any methods that are inappropriate for your teaching method [style]? Describe why?
6) Is the class fulfilling your expectations? Explain briefly.
7) In general, what do you like most about this class so far?
8) What do you like the least about the teaching methods and style of the class so far? How would you change it?

The following table provides a summary of the responses for the first six questions, where responses were coded as a "yes" or "no" category items.

Table 1: Summary of Personal Journals at the End of the Intervention Programs of Summer 2000 and 2001.

Q.	Yes	No
1	37	25
2	6	46
3	52	0
4	9	43
5	0	52
6	52	0

Some of the explanations for Table 1 are summarized below. Furthermore, many other comments provided in the personal journal section were also stated in the End of Course Evaluation section. In the first question, those who said they used concrete materials and manipulative in their classroom instructions cited only lessons that involve geometry and/or addition and subtractions of whole numbers.

Two of the respondents in question 1 admitted that they taught only sciences, (Biology, Chemistry, and maybe Physics), which required hands-on activities and labs. In relation to the similarities between their past teaching practices and the methods of the intervention program, some participants indicated that they involved their students by giving the opportunity to ask questions freely during study periods or specially designed times for problem solving periods. Some of the respondents also stated they let students work problems on the board. However, the majority of the participants replied that before the course, they heavily relied on "chalk and board" instructional practices. Many also stated that they did not understand what a "student-centered" curriculum or instruction was. Others confirmed that they were not sure of what cooperative learning meant and its contribution to students learning, or the "appropriate" teacher-student interaction and relations should be, before this course. The majority of the respondents in question four mention that the intervention program would help teachers deliver their instruction easily, smoothly, and effectively. To this end, they would be more open-minded in teaching mathematics, and they would be sharing their ideas and accepting new ideas from their colleagues in their schools.

For questions 3 and 5, all wrote that the whole activities and teaching models demonstrated in the program might be replicated and practiced in their own classrooms. However, some cautioned that heavy workload and high number of students in the classroom might prevent them from taking full advantage of the summer program. A respondent, for instance, stated:

> …while we hear a lot about student-centered instructional practices, our circumstances are not conducive for teachers to learn about or practice such teaching strategies. The books and the curriculum do not support that yet. We never had such an exposure until this summer. However, we cannot wait until someone else creates a better condition for us to be better teachers. I think we are given a good opportunity this summer to teach ourselves and teach our students better. I will try any way...

End of Course Evaluation

This is a three-part questionnaire which includes the rating of teachers' familiarity with student-centered teaching practices, the extent to which the course will help them teach mathematics effectively, and two open-ended questions. Table 2 and 3 illustrate the results of the summers 2000 and 2001 end of course evaluations respectively.

Rating of the major activities conducted during the summer program used the following scale system: (4) This course provided my first experience with this activity or method, (3) I have seen this activity or method once or twice, but have never used it, (2) I am very familiar with this activity or method, but have never used it, (1) I have used this method or activity once or twice, (0) I use this activity or method often.

Table 2: Level of Familiarity of Participants with Student-centered Teaching Models before the Summer Mathematics Methods Course.

Roll No.	Topics Covered	Rating Scale					
		4	3	2	1	0	N/O
1	Teaching sequences and series using concrete materials Such as matchsticks, or geometrical figures	37	13	1	0	0	0
2	Teaching whole number multiplication using Lattice Multiplication algorithm	40	11	0	0	0	0
3	Teaching whole number multiplication using the array or rectangular method	36	11	1	1	0	0
4	Teaching division of whole numbers using the repeated subtraction, sharing, or re-grouping models	31	15	3	1	0	0
5	Teaching multiplication and division of integers using the pattern model	35	12	0	3	0	0
6	Adding and subtracting fractions using the vertical and horizontal strip model	36	12	2	1	1	0
7	Multiplying fractions using the intersection of vertical and horizontal strip models	32	15	2	1	2	0
8	Making connections between mathematics topics and other subjects (e. g. expanding $(a+b)^2$ by finding the area of a square	31	14	3	2	1	0
9	Finding GCD using the Euclidean algorithm	34	10	5	2	1	1
10	Making connections between fractions, decimals, and percentages using an area of a square of dimensions 10 by 10.	26	13	4	0	1	1
11	Use of colored chips (or other objects) to develop operations On integers	30	16	4	0	0	0
12	Use of previously learned concepts to develop algorithm, such as the division algorithm	27	20	2	1	0	0
13	Use of developed mathematical properties to understand common algorithms, such as division of fractions	32	16	2	1	0	0
14	Use of arrays to develop concepts of GCF*	18	9	0	0	1	1
15	Use of paper folding activity (square fraction) to develop fraction concept*	23	3	2	0	0	1
16	Use of card games to develop concepts of equivalent fractions, percents, and decimals*	20	7	0	1	0	1
17	Use of physical models to solve simple algebraic equations*	18	8	0	3	0	0
18	Teaching the triangle inequality through building 'possible' and 'impossible' triangles*	20	5	1	2	1	1
19	Teaching similarity properties through projection of geometric Figures (rubber band 'stretcher' activities)*	23	5	0	0	0	1
20	Teaching Pythagorean Theorem trough the creation of several different types of triangles*	12	11	4	0	1	1

*Activities 14 to 20 were included in the summer 2001 program only.

Table 2 indicates that of the 866 responses, 787 (91%) rated their lack of knowledge or understanding of such teaching methodologies as 4 (the intervention program was their first exposure to such instructional practices), or 3 (they had heard about some of the models, but never used them in their classrooms), prior to intervention.

The rating scales for the potential benefits of the intervention program to the participating teachers (Table 3 below) are: (4) Strongly Agree, (3) Agree, (2) Neither Agree nor Disagree, (1) Disagree, (0) Strongly Disagree.

Table 3: Potential Benefits from the Concepts and Applications of the Intervention Program.

Roll	Potential Benefits	Rating Scale					
No.		4	3	2	1	0	N/O
1	This experience will help me to become a better and effective mathematics teacher.	44	7	0	0	0	0
2	The instructional method helps students develop inductive and deductive reasoning.	48	3	0	0	0	0
3	This instructional method helps students to become active learners of mathematics.	45	6	0	0	0	0
4	This instructional method helps students understand mathematics better.	47	4	0	0	0	0
5	This instructional method helps students make connections among mathematical concepts, topics, and other fields.	41	10	0	0	0	0
6	This instructional method helps students develop meaningful learning.	43	7	0	0	0	1
7	This instructional method helps students develop a deeper interest in mathematics.	46	4	0	0	0	1
8	I will use most or some of the methods and models I have learned in this course to teach mathematics.	32	16	0	0	0	1
9	I have found this course to be very helpful in my personal and professional development.	44	6	1	0	0	0
10	I recommend this course to be integrated in the diploma program requirements in the future.	39	10	1	0	0	0

On the potential benefits of the summer intervention program for the participants' future use in Table 3 above is more than 84% (429 of the 510 responses rated the course as very useful (4), 15% as useful (3), and less than 1% rated it at 2 or less).

The respondents were provided with two open-ended questions. Their responses are summaried as follows. The first question asks them to cite some examples of the models of instructions presented in the program they will use and which model will they modify and use or not use. Almost all of the participants stated that they could use all or most of the mathematics teaching models presented in their classrooms. Many of them also pointed out that most of the materials used during the summer intervention program could be made with locally available materials with no cost or very low cost. Some (six of the fifty-two participants) listed that they could apply all models provided that materials and funds were available. Three of the respondents claimed they would not use some models, such as, models that involve colored chips or the Euclidean Algorithm.

In the other open-ended question the subjects were asked to comment and recommend on the strengths or weakness of the course. They listed the following comments:

- This course made teaching and learning more meaningful.
- This course changed the way I perceived mathematics teaching and learning, and it will change the way I will teach.
- I have gained a great deal of personal and professional development from this course.
- This course will help teachers gain confidence in their teaching ability and help teachers know mathematics better.
- Large class sizes and lack of resources may prevent me from applying all the models of this course in my own classes.
- I will arrange workshops for my school and for teachers in neighboring schools to share my new knowledge of teaching.

The respondents also recommend the following points for improvement of the course:

- Integrate this course and its activities with the college's Math 251 (Mathematics methods course).
- Continue the program in a sustainable manner.
- Require all students (participant prospective teachers) to attend this course each day.
- Offer the course after the final exams of the college.
- Make this course part of the college curriculum.
- Reduce class presentations by pre-service teachers so that there will be more time to show us additional models.
- Continue with class presentations, because they give us a chance to see how we can apply our new knowledge in our classrooms.
- Include computers as mathematics teaching tools in the course.
- Materials you gave us at the end of the course should have been given to us at the beginning of the course.

Mid-semester Student Performance Test

Finally, the study also attempted to evaluate the impact of the intervention program in the classrooms. By mid-semester, at the end of November or at the beginning of December, most of the materials discussed and modeled in the summer program would be covered by the teachers in their classes. Therefore, mid-semester exams were prepared based on the Ethiopian middle school mathematics curriculum, and administered in twenty-nine classes for 580 students during the fall of 2000 and 2001. The mid-semester exams consisted of 20 multiple-choice questions. The breakdown of the number of right answers (out of 400) by each teacher's class is tabulated as follows.

Table 4: Student Mid-semester Test Results by School (Number of Correct Responses).

Grade 7	169	126	135	164			(Control Group)
	229	156	171	151			(Experimental 2000)
	173	193	189	217			(Experimental 2001)
Grade 8	199	158	156	178	166	152	(Control Group)
	152	239	178	147	139	176	(Experimental 2000)
	204	205	164	175	145		(Experimental 2001)

The following SAS output shows the average number of problems solved correctly, categorized by grade and year. Treatment levels (trt) represent:

C = Control Group
E = Experimental Group in 2000
X = Experimental Group in 2001

Table 5: Average Number of Correct Responses by Group.

Grade level	Trt Level	N	Mean	Std Dev
7	C	4	148.500000	21.2053452
7	E	4	176.750000	35.8550322
7	X	4	191.000000	16.9901932
8	C	6	168.166667	17.6908639
8	E	6	171.833333	36.4824159
8	X	5	178.600000	25.9672871

Table 6: Average Number of Correct Responses by Control Group, Experimental Group 2000, and Experimental Group 2001.

C	10	160.300000	20.6615585
E	10	173.800000	34.2695200
X	9	184.111111	22.0932368

From the above three tables, it can be observed that the number of correct responses in the mid-semester student test, and the experimental groups have the higher number of correct responses.

The data from the mid-semester exams of the control group and the experimental group are further analyzed using the Contrast Statistical Method. The following table is the Contrasts SAS output.

Table 7: Contrasts between Experimental and Controlled-group.

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
c vs e - 2000	1	1222.408333	1222.408333	1.65	0.2111
c vs x - 2001	1	3233.005128	3233.005128	4.38	0.0477
year 2000 vs 2001	1	2076.684494	2076.684494	2.81	0.1071

The above contrast table shows that the difference between the controlled- group means and the 2001 experimental group means are statistically significant.

Analyzing the Research Results

The results of the three assessment tools for this paper confirm that Tigrai middle school mathematics teachers (Grade 5-8) reacted positively to the ideas and practices of an American way of student-centered teaching methods. The data and interactions with teachers during and after the intervention programs also revealed the main teaching practices of Tigrai middle school mathematics teachers adopted from the summer programs.

The attitudes and values given to the mathematics methods course, that was based on some of the American teaching practices, was evident in the personal journals of the on-going assessment of the participants. The overwhelming majority of the participants (94% of the responses) stated that the models and instructional methods used in the summer program were not similar to how they taught in their own classrooms. On the other hand, more than 93% of the responses indicated that the teaching methods, models, and manipulative used in the course would be appropriate and easily replicable in their own classrooms. However, some reservations that were aired were heavy workload, large numbers of students in the classroom, and the inconsistency of the books and curriculum with student-centered instructional methods may limit the teachers' inability to apply some of the knowledge acquired from the summer program.

The end of course evaluation by the participant teachers further confirmed the pre- and post-test results as well as the participants' personal journals' summaries. From the end of course evaluation, it can be generalized that the participant teachers' prior understanding and the practice of student-centered instructional practices were nonexistent or minimal. Out of the 866 responses, (91%) rated their lack of knowledge or understanding of such teaching methodologies as 4 (the intervention program was their first exposure to such instructional practices), or 3 (they had heard about some of the models, but never used them in their classrooms).

On the potential benefits of the summer intervention program for the participants' future use, more than 84% of them rated the course as very useful (4). The comments and suggestions offered in the end of course evaluations were also very positive. The overwhelming majority of the participants suggested that such activities should be part and parcel of the college curriculum. Many of them also recommended that this course and similar activities ought to be extended to include in-service teachers in a continuous and sustainable way. All stated that they will use some or most of the teaching models and manipulative demonstrated in the course. However, some presented few concerns that the heavy workload, the large number of students in the classrooms, and the lack of resources and materials may hinder them from taking full advantage of the summer program.

The last assessment tool for the study attempted to examine whether or not students taught by teachers who participated in the intervention program (experimental group) performed better on the same test than students taught by teachers who did not participate (control group). The data and statistical analysis of Table 4 to 7 show some differences of test results between the experimental group and control group students.

The average number of correct answers by group, in Table 5 and Table 6, indicate that the experimental groups of both grades and years did better than the control group. A further statistical analysis of contrasting the data reveals that the difference between the means of the 2001 experimental group and the control group is statistically significant at the 5% level (See Table 7). On the other hand, the mean for the 2000 experimental group is larger than the mean for the control group and the mean of the 2001 experimental group is larger than the mean of the 2000 experimental group, but these differences are not statistically significant.

Conclusion

Participant teachers in this study reacted positively to the standards-based instructional practices. They also showed the willingness to take the risk of trying and exploring the new teaching strategies in their own classrooms. They designed their mathematics lessons to help students develop conceptual and procedural understanding of the mathematics they teach.

Many of them have already started making and using manipulatives and teaching aids from locally available materials. They believe the use of appropriate concrete materials in the classroom creates active learning. Active learning, in turn, helps students to understand better concepts and procedures in Mathematical Algorithms, applications, and problem solving.

Due to the recommendation of the Tigrai Bureau of Education and the availability of funds, similar intervention programs to the mathematics methods course were conducted in the sciences and English. The instructors of the two departments were also participants and beneficiaries of the programs in their areas, as well.

The Chairman of the Department of Mathematics also taught the mathematics methods course (Math 251). Following is a translation of his impression of the mathematics intervention program in the summer of 2000.

> I am very glad to attend and participate in such a course where mathematics teaching is heavily tied in and with action. Throughout my teaching and learning career, be it in elementary school, in the high school, or in the university, I have never had such an opportunity and experience….I have been teaching Math 251 in this college for the past three semesters. In this course there have been many areas and aspects of the course that were not clear to me. Now, I can say with confidence that most of my questions have been answered in this course. I can say that I have learned how to teach myself as well. Math 251 would be meaningful only if the necessary mathematics actions were incorporated with the theory.

At the time when the Ethiopian educational system is under a major reform movement, it is with high hopes that this study offers some alternatives in the college's and the Region's teacher preparation programs. Above all, the study opens great opportunities for further research on the effects of the Standards-based American teaching practices in Tigrai, and Ethiopia in general.

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