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Implication of Mathematical tools to Teachers' Method of Teaching High School Mathematics: The case of Mekelle Zone, Tigray, Ethiopia

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ABSTRACT

Education with science and mathematics as its major components determines the level of welfare of people and a nation. Nowadays, great attention is given to technological advancements and mathematics education. Hence, this paper explicitly discusses the use of mathematics laboratories and their implication for teaching mathematics, finding out the practices and impact on teaching mathematics and teachers' frequency of using teaching aids (manipulatives) in high schools of Mekelle zone. Manipulatives are valuable aid to teachers that can be used by analyzing students' concrete representations of mathematical concepts. In addition to this, topics like geometry and measurement are topics that are frequently taught using tools. On the contrary, solving equations, relations, and functions is rarely taught using these manipulatives. This study indicates that there is no direct correlation between teachers' teaching experience years and the use of manipulatives in their classrooms. It is, therefore, recommended that mathematics teachers should get training and workshops on the use of teaching aids (manipulatives), useful software like (geogebra, sketchpad, and other timely used technologies) and other methods of teaching mathematics in mathematics laboratories.

Keywords: Tools, Mathematics laboratory, Manipulative, Models, Mekelle, Ethiopia.

1. INTRODUCTION

Developing countries like Ethiopia have been facing problems in designing and implementation relevant educational policy to disseminate quality education and Training. The issues are mainly indications of the teaching-learning processes. Education with science and mathematics as its major components determines the level of prosperity and welfare of people and a nation at large. In the case of Ethiopia, the promotion of science, mathematics, engineering, and technology education (science and technology) is visible at all levels of the education system (general education, TVET and higher education). Within general education system in Ethiopia (grades 1-12), science and mathematics education is essential for cultivating a generation of scientists and for poverty reduction of the population. Greater understanding of the relevance of science and mathematics education for development is the foundation of any effort to improve science and mathematics.

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However, there is a general dissatisfaction in the quality of education. The results are in general unsatisfactory. Students fail to grasp the spirit of the subject and often unable to apply their knowledge to advanced work or to practical problems. Generally, students are afraid of studying mathematics (Bezabih, 2008). And the society and most students view Mathematics as a collection of rigid rules and mysterious procedures that seem to be unrelated to each other and require total mastery with little or no understanding.

A lot of research studies worldwide had been done on the methods of teaching mathematics comparing one another and emphasizing the student-centered approach for better performance. Yet, the problem is still recurring, to offer quality training and education and achieve its national educational goal. Ethiopia has been continually revising its curriculum to suit it to the needs of society. These include, among other things, content organization, methodologies of teaching, teacher preparation (Capacity building) and implementation strategies. The implementation of active learning method is imperative to develop the problem-solving skills and increasing competencies of the students when learning at various levels. Yet, here we again need to know how to implement that active learning which is one of the strategies of teaching. The secondary schools are the stepping stones to colleges and university education. However, the results in mathematics and physics are low as compared to the other subjects here in Mekelle, Ethiopia. Hence, it is believed that students understand abstract mathematical ideas better when they solve problems through manipulatives.

Hence, the team tried to investigate the use of mathematics laboratory and modern manipulative in teaching mathematics and teachers' practices in using teaching aids (Algebra tails, dies, geoboards, etc) in high schools. The results of this study obtained from 45 high school mathematics teachers in Mekelle, therefore, will provide information about the problems that high school teachers face in making use of teaching aids and software packages which can help to teach mathematics in high schools. The result may also be input to support the educational process of Mekelle zone by providing solutions for the current problems experienced by students, teachers, school authorities, and government bodies at different levels.

Before the rapid development of technology, the teaching process was reduced to the teachers' verbal presentation of material and using chalk to write on the blackboard. Although speech remains the most important asset in the teacher's work, today's teaching process is difficult to imagine without the use of different modern teaching and learning resources

(Bušljeta, 2013). The contribution of these resources to the teaching and learning process is diverse. Since students are surrounded by visual representations and audiovisual and auditory materials daily, owing to media such as television and the internet, it is difficult to imagine today's educational process without the use of various teaching and learning resources. But, in countries like Ethiopia, most public and private schools do not use technology in teaching mathematics. In this light, a study was conducted to assess the availability of mathematical tools in schools, analyze the extent of using mathematical tools by high school teachers, analyze the implication of using mathematical tools (manipulatives) to teachers', understanding in their instructional process, and recommend possible intervention mechanisms.

2. LITERATURE REVIEW

For the last two decades, many trials and amendments have been made at all educational levels to suit the goals of education to the needs of the society (OECD, 2010). Since high school education is the basis, governments made special emphasis on the re-alignment of school curriculum with universities. The study of Mathematics has long been recognized worldwide as important in the understanding of other subjects like chemistry, biology, and physics. (Education, Education Sector Development Program, 2010)

The subject mathematics and its teaching and learning processes are essential components of mathematics education in almost all schools and at all levels. With this major idea in mind, these components should, therefore, be supported by research results in the area. Thus, the documents we have tried to review focuses on research related to the attitude of teachers towards mathematics (including numbers and their operations), learning environment in the classroom, and the use and effectiveness of technology (including hands on materials and software packages) in mathematics classrooms. For example, by 1990, basic cognitive research on the important roles of representations in learning abstract mathematics and science concepts had largely concluded that the application of technology must be domain specific to be effective (Kaput, 1992). Thus, summaries of different research works and positions of researchers on these issues are considered in this review.

2.1. Role and Impact of Using Manipulatives

One way to help slow learner pupils' understand mathematical concepts or ideas are to use the laboratory approach (Loh, 2002). In this approach, the learner can have hands-on experience through the manipulation of concrete materials from which he/she can see how some ideas or concepts have come about. All types of students need to develop the ability to select appropriate manipulatives, electronic tools and computational tasks to investigate mathematical ideas and to solve problems. Using manipulative to construct representations help students to

- See arrangements and relationships,
- Make connections between the tangible and the abstract,
- Test, revise and confirm their reasoning and this helps students check the solution, and
- Remember how they have solved a problem and communicate their reasoning to others.

As a result, this helps to encourage active participation in the classroom. Manipulatives are necessary tools for supporting the effective learning of mathematics by all students. These concrete learning tools invite students to explore and represent abstract mathematical concepts in varied, concrete, tangible and visually rich ways. In addition, technology makes possible for students to see connections between multiple representations of a concept and to gain insights into abstract entities such as functions (Merrilyn Goos, 2007). In parallel, doing mathematical concepts using manipulatives make classrooms active and it encourages teamwork with an active participation of all the members of the group.

Different studies concluded that mathematics achievement is increased through the long-term use of concrete instructional materials and that students' attitudes towards mathematics are improved when they have instruction using concrete materials provided by teachers knowledgeable about their use. Manipulative materials can (1) help students understand mathematical concepts and processes, (2) increase students' flexibility of thinking, (3) be used creatively as tools to solve new mathematical problems, and (4) reduce students' anxiety while doing mathematics. Manipulatives are also valuable aids to teachers. By analyzing students' concrete representations of mathematical concepts and listening to their reasoning, teachers can gain useful insights into students thinking and providing support to help enhance their thinking. Mathematics teachers have intended to use mathematical tools which support mathematical activities. Such materials as algebra models, kites, dies, geoboards and other locally made teaching aids are essential for advancing the teaching methods.

2.2. Mathematics Laboratory

Mathematics laboratory is a specific place with relevant and up-to-date equipment known as instructional materials Manipulatives, designated for the teaching and learning of mathematics and other scientific or research works.

Mathematics laboratory can contribute to the learning of the subject in the following sense:

1. It provides an opportunity to students to understand and internalize the basic mathematical concepts through concrete objects and situations.
2. It enables students to verify or discover several geometrical properties and facts using models or paper cutting and folding techniques.
3. It helps students to build interest and confidence in learning the subject.
4. The laboratory provides an opportunity to exhibit the relatedness of mathematical concepts with everyday life.
5. It provides greater scope for individual participation in the process of learning and becoming autonomous learners.
6. It provides scope for greater involvement of both the mind and the hand which facilitates cognition.
7. The laboratory allows and encourages the students to think, discuss with each other and the teacher and assimilate the concepts in a more effective manner.
8. It enables the teacher to demonstrate, explain and reinforce abstract mathematical ideas by using concrete objects, models, charts, graphs, pictures, posters, etc.

3. DATA ANALYSIS AND DISCUSSION

3.1. Data Collection Method

Data was collected from 7 high schools and preparatory schools of Mekelle zone. Among all teachers working in these high schools, 45 teachers including department heads were selected randomly and purposefully for the department heads. The study team has employed mixed research approach (quantitative and qualitative) which included both closed and open-ended questions. Table 1 highlights the social and demographic characteristics of the 45 respondents from Mekelle city from seven high school and preparatory school teachers.

Table 1. Demographic characteristics.

S. No.	***Observation points***	***Values***	***Frequency***	***Percent***
1	Sex	Male	30	66.7%
		Female	15	33.3%
2	Age	20-30	4	8.9%
		30-40	26	57.8%
		40-50	13	28.9%
		Above 50	2	4.4%
3	Educational level	Diploma	0	0.0%
		BSc/ Bed	40	88.9%
		MSc/ Med	5	11.1%
		PhD	0	0.0%
4	Experience	Below 3 years	0	0.0%
		3-6 years	1	2.2%
		6-9 years	1	2.2%
		9-12 years	9	20.0%
		Above 12 years	34	75.6%

Table 1 indicates that about 75.6 % of the teachers have 12 and above years of teaching experience and 89% of them are BSc/ BEd holders. The data show majority of the teachers are with required qualification to teach high school Mathematics (Grade 9 & 10).

3.2. Discussion and Results

Table 2 shows that nearly 87% of the teachers responded that teaching using mathematical tools is very interesting. The number of respondents who said students feel that mathematics is an easy subject when it is taught by tools is 36 teachers out of 45.

Table 2. Feelings and rate.

S. No.	***Questions***	***Observations***	***Frequency***	***Percent***
1.	How do you rate teaching mathematics using teaching aid?	Interesting	39	86.7%
		Moderate	5	11.1%
		boring	1	2.2%
2.	What do students feel when they are taught mathematics by the help of teaching aid in?	Easy	36	80.0%
		Moderate	8	17.8%
		Hard	1	2.2%

Table 3 indicates the responses on whether there is a separate room for mathematics laboratory in their school or not. Accordingly, 97.8 % said that there is no separate lab room for mathematics. Even if standards of the ministry of education show that a school should have a separate room for mathematics laboratory, almost all schools don’t have a laboratory.

Table 3. Existence of laboratory.

S. No.	***Questions***	***Observations***	***Frequency***	***percent***
1	Is there any separate classroom for mathematics Laboratory in your school?	Yes	1	2.2%
		No	44	97.8%

Table 4 indicates that 75 % of the respondents did not take any additional training or workshop on the use of manipulatives like Algebra models and other mathematics tools which help them teach mathematics with teaching aids.

Table 4. Attending for a workshop.

S. No.	***Questions***	***Observations***	***Frequency***	***percent***
1	Have you ever attended any training/ workshop on Algebra models using teaching aids?	Yes	11	25 %
		No	33	75 %

Table 5 and figure 1 indicate that a relatively large number of teacher respondents replied that they use mathematical tools for topics such as Measurement and Geometry as well as probability. It can be observed from table 5 that topics such as number theory and solving equations are taught without using tools.

Table 5. Topics in relation to the frequency of using mathematical tools.

S. No.	***Observation***	***Rate***	***Frequency***	***Percent***
1	Number system and Number theory	Never at all	19	43.2%
		Rarely (once in a topic)	12	27.3%
		Sometimes (two or three times per week)	12	27.3%
		All through the topics	1	2.3%
2	Solving equations and computations	Never at all	25	56.8%
		Rarely (once in a topic)	8	18.2%
		Sometimes (two or three times per week)	10	22.7%
		All through the topics	1	2.3%
3	Measurement and geometry	Never at all	1	2.2%
		Rarely (once in a topic)	8	17.8%
		Sometimes (two or three times per week)	21	46.7%
		All through the topics	15	33.3%
4	Relations and functions	Never at all	9	20.5%
		Rarely (once in a topic)	12	27.3%
		Sometimes (two or three times per week)	20	45.5%
		All through the topics	3	6.8%

5	Coordinate Geometry	Never at all	6	13.6%
		Rarely (once in a topic)	16	36.4%
		Sometimes (two or three times per week)	17	38.6%
		All through the topics	5	11.4%
6	Data collection and analysis	Never at all	11	24.4%
		Rarely (once in a topic)	13	28.9%
		Sometimes (two or three times per week)	19	42.2%
		All through the topics	2	4.4%
7	Probability	Never at all	3	6.7%
		Rarely (once in a topic)	11	24.4%
		Sometimes (two or three times per week)	21	46.7%
		All through the topics	10	22.2%

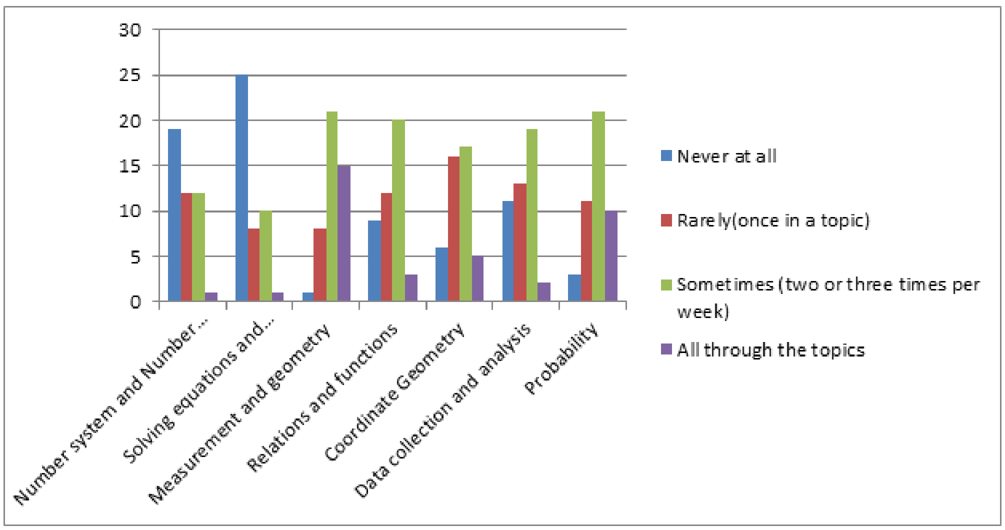

Figure 1. Bar charts for different components.

Table 6. Rating of topics with frequent use of teaching aids.

S. No.	***Questions***	***Observations***	***Frequency***	***percent***
1.	From all the topics in Table 5, rate three topics in which you use teaching aids frequently?	Number system and Number theory	3	6.8%
		Solving equations and computations	1	2.3%
		Measurement and geometry	22	50.0%
		Relations and functions	7	15.9%
		Coordinate Geometry	3	6.8%
		Data collection and analysis	0	0.0%
		Probability	8	18.2%

From results of table 6, only 22 (50%) respondents said that they use teaching aids frequently when they teach topics such as measurement and geometry as well as probability (18.2%). From these sample data, it can be observed that math teachers are not using teaching aids when teaching different topics/ chapters. From table 7, 36 (80%), 28 (62.2%) and 41 (93.2%), respectively, have replied they did not take any software training, no internet service in their school and they did not apply any software for teaching mathematics.

Table 7. Response on Technology related questions.

S. No.	***Questions***	***Observations***	***Frequency***	***Percent***
1	Is there an ICT lab in your school?	Yes	28	62.2%
		No	17	37.8%
2	Have you ever taken any software training that helps you teach mathematics?	Yes	9	20.0%
		No	36	80.0%
3	Do you have an internet service in your school?	Yes	17	37.8%
		No	28	62.2%
4	Have you ever used any software to teach mathematics?	Yes	2	4.5%
		No	41	93.2%
		3	1	2.3%

Table 8. Response on Training related questions.

S. No.	***Questions***	***Observations***	***Frequency***	***Percent***
1.	Deepening mathematics knowledge	No need	1	2.3%
		Less Important	7	15.9%
		Moderately needed	10	22.7%
		Highly needed	26	59.1%
2.	Understanding students participation in mathematics	No need	6	13.3%
		Less Important	11	24.4%
		Moderately needed	14	31.1%
		Highly needed	14	31.1%
3.	Training on how to use technology in mathematics instruction	No need	2	4.4%
		Less Important	8	17.8%
		Moderately needed	12	26.7%
		Highly needed	23	51.1%
4.	Training on how to assess students learning in mathematics	No need	3	6.8%
		Less Important	7	15.9%
		Moderately needed	15	34.1%
		Highly needed	19	43.2%
5.	Training on how to teach mathematics in a class that includes students with special needs	No need	2	4.4%
		Less Important	5	11.1%
		Moderately needed	18	40.0%
		Highly needed	20	44.4%

Table 8 presents trainings are necessary in different areas. Therefore, according to the respondents, on deepening mathematical knowledge (contents) is highly needed (59.1%), the use of technology (51.1%), assessment of student learning (43.2%) and treatment of students with special needs (44.4%) is highly needed for math teacher.

4. CONCLUSION AND RECOMMENDATIONS

4.1. Conclusions

From the discussions made on this study, one can observe that most high school Teachers of Mekelle zone are not using manipulatives to the required level. It can be observed that some mathematics teachers also perceive that there is no need a laboratory for teaching mathematics. And all schools in Mekelle do not have a separate room for mathematics laboratory. Those teachers who use mathematics tools (manipulatives) are still using for some specific topics like geometry and measurement (shapes of figures, angles, etc). The aids mostly used are locally made and they are not accurately measured. On the other hand, most teachers never use teaching aids (manipulatives) for topics like number system and number theory, solving equations and computations and rarely use these tools for relations and functions, data collection and analysis. In this study, it is possible to conclude that there is no direct correlation with the use of tools and number of years of teaching experience.

4.2. Recommendations

Based on the results of this study, Governmental, and non-Governmental organizations should share their part to equip high schools with internet access and other technologies. So, teachers should be acquainted with new teaching aids. Based on the results of this study, the following recommendations are made.

1. Mathematics laboratory should be established in each school. And it should be equipped with different materials such as Algebra models, Geoboard, and other softwares like (Geogebra, sketch pad) and many other locally made objects.
2. High school and preparatory school teachers should be given on job training for the use of new technology in teaching mathematics. This may be done depending on selected topics/chapters and grade levels they teach.

3. Curriculum planers in teacher education should modify courses which are related to teaching mathematics. Higher institutions should support these high schools and preparatory schools by developing new tools for teaching mathematics.
4. Since teaching with tools is good, teaching aids in the educational system should be formal, institutionalized for making, distributing and training for teachers.
5. School administrators of the local region should establish an office for facilitating, distributing mathematical tools.

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6. CONFLICT OF INTERESTS

No conflict of interests

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