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**Abstract**

Active learning and practical learning are central themes of modern learner-centered pedagogy. Because of its effectiveness in the area of teaching strategies, researchers around the world have endorsed active learning and learning by doing for the teaching and learning process. Learning and practical learning are central themes of modern learner-centered pedagogy. Because of its effectiveness in the area of teaching strategies, researchers around the world have endorsed active learning and learning by doing for the teaching and learning process. The purpose of this research was to investigate the practices and challenges regarding the mathematics laboratory in Punjab at the school level. A descriptive survey design was used for the study. The main instrument used for the study was the teacher questionnaire. The population of this study was all secondary schools and mathematics teachers of district Chakwal. This study was limited to only one District of Punjab.

**Keywords:** Active Learning, Mathematics Laboratory, Learner-Centered Pedagogy, Educational Challenges, Policy Implementation

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## Title

### Practices and Challenges Regarding Mathematics Laboratory for Pedagogical Purposes at Secondary School Level

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#### Abstract

Active learning and practical learning are central themes of modern learner-centered pedagogy. Because of its effectiveness in the area of teaching strategies, researchers around the world have endorsed active learning and learning by doing for the teaching and learning process. The purpose of This research was to investigate the practices and challenges regarding the mathematics laboratory in Punjab at the school level. A descriptive survey design was used for the study. The main instrument used for the study was the teacher questionnaire. The population of this study was all secondary schools and mathematics teachers of district Chakwal. This study was limited to only one District of Punjab.

**Keywords:** [Active Learning](#), [Mathematics Laboratory](#), [Learner-Centered Pedagogy](#), [Educational Challenges](#), [Policy Implementation](#)

#### Introduction

The mathematics laboratory is an interesting concept in the field of mathematics education and became popular in 1994. In many developed countries, mathematics laboratories play an important role in the regular curriculum. It has grown a long way to improve mathematics at the

elementary, secondary, and high secondary levels. Therefore, teaching and learning mathematics in schools can be considered more action-oriented and willing to experiment.

A long tradition of educational research has encouraged the use of active learner-centered methods in schools, particularly through the use of



educational laboratories (Abasi, 2018). A student-centered approach to teaching is the most beneficial and appropriate form of teaching mathematics. Provide active student participation for fruitful learning. Teachers rarely mentioned crowded classes. This issue was mentioned only once by him as a reason for avoiding the "gaming" technique. Likewise, no physical environment or material was given as a reason or excuse for avoiding a particular technique (Acharya, 2017). However traditional methods are still practiced in our educational system, and it seems impossible to change the current culture of mathematics education from a teacher-centered to a student-centered teaching approach at the school level.

This method is based on the philosophy of pragmatism and the principle of this philosophy is learning by doing and experiences. It is based on the student's rhythm. It helps to clarify basic concepts and ideas Laboratory method develops a habit of scientific inquiry and investigation in the child and it presents mathematics as a practical subject. Mostly it is taught through traditional methods like lecture methods. In the neighboring countries that are very good in mathematics like China, Singapore, and Japan, mostly Mathematics is taught through real-life problem-solving methods (Núñez, 2020). Traditional teaching methods which are mostly used in classrooms while teaching Mathematics cause math anxiety and math phobias among the students (Foley et al., 2017). So for a better understanding of mathematical concepts and to make mathematics interesting, it is necessary to adopt new modern approaches to teaching Mathematics. In many research studies, activities-based and inquiry-based instruction is suggested for teaching science subjects and for Mathematics. But not much work has been done in this regard, especially in Mathematics.

### **Purpose of Mathematics Laboratory**

The purpose of setting mathematics laboratory in school is to provide the opportunity for the students they learn and explore mathematical concepts and verify mathematical facts and theorems through a variety of activities using different materials. Such activities may be carried out by the students or the teacher. These activities help the learner to explore or learn stimulate interest and develop a positive attitude toward

learning mathematics. It makes teaching mathematics interesting, quicker easy, and better understanding. The main purposes of the mathematics laboratory that can contribute to the learning of mathematics are as follows:

- To make a clear concept about the abstract mathematical ideas
- To emphasize learning by doing through readily accessible rich manipulative materials
- To develop confidence in students to learn mathematics
- To generate interest and a positive attitude toward the subject. Núñez, R. (2020).
- To make the students divergent thinkers and become autonomous learners
- To make children look for a pattern and make them curious to ask questions
- To provide the opportunity for exhibiting the relatedness of mathematical concepts with
- Everyday Life Needs and Importance of Mathematics Laboratory

The essential equipment and materials concerning the mathematics classroom learning activities are kept in the mathematics laboratory. The main aim of the mathematics laboratory is to provide facilities for effective teaching and make learning easier through the use of concrete materials and real objects to grasp abstract mathematical concepts (Rathod & Amin, 2020).

The purpose of setting mathematics laboratory in school is to provide the opportunity for the students they learn and explore mathematical concepts and verify mathematical facts.

### **The rationale of the Study**

In Trend in International Mathematics and Science Subject (TIMSS) 2019, Pakistan took place for the first time and Pakistan's mathematic performance was very poor. In terms of form, Pakistan ranked second from the bottom. Statistics show that 27% of 4th grade students in the country achieved low international standards in Mathematics, 8% achieved international intermediate scores and only 1% achieved high international standards. This report shows that mathematics education in Pakistan is facing serious challenges. It seems that overall; the position is unsatisfactory in mathematics education due to traditional methods of teaching used at the school

level. As a result, now math has become a difficult, uninteresting, and unattractive subject for a large number of students. The variation in results shows an alarming situation about the difficulty in understanding Mathematics of students in elementary school. In such situations, teachers need advanced techniques to solve problems scientifically. Núñez, R. (2020).

Active learning and practical learning are central themes of modern learner-centered pedagogy. Because of its effectiveness in the area of teaching strategies, researchers around the world have endorsed active learning and learning by doing for the teaching and learning process. This can only be done through the development of a specific active learning model for the teaching of mathematics. Caviola, S. et.al (2021).. Applying mathematics laboratory simulation materials can enhance students' understanding of the concepts of systems of linear equations. This is indicated by an increase in the average student comprehension rate of concepts. Maryanti, I. (in 2021). Research by Lahcen, R., et.al (2019) "Promoting proactive behavior through motivation: The case for asking for "math laboratory hours" reaffirms that it is very effective to request weekly laboratory hours in a college algebra course. The laboratory method is a combination of activity-based learning, problem-based learning, project-based learning, cooperative learning, and more.

### Literature Review

Talking about the role of mathematics in the 21st century is deeply linked to creative and critical thinking as it is a fundamental skill for the future due to its ability to explain things logically and underpin our thoughts. In this century, the challenges encountered in daily life are growing difficult and complex. It is significant for each individual to understand and know the role of mathematics in real life so that individuals can evaluate and consider appropriately the use of mathematics to satisfy the need to become a member of society constructive, caring, and willing to reflect. Math skills are essential to living successfully in the 21st century. Competency requirements in rapidly growing professions include digital literacy problem-solving, communication, cooperation, critical thinking, creativity, and innovation (Rizki & Priatna, 2019; Wijaya, 2016)

The teaching of mathematics is considered challenging and requires a comprehensive set of appropriate teaching strategies to bridge the gap between theory and practice in mathematics education and ensure the active participation of students to learn effectively Maheshwari, V.K. 2018

(2018). This set of practical learning strategies can support students in math and engage them enthusiastically in the learning process. This can only be done through the development of a specific active learning model for the teaching of mathematics. Bouck, E. C. et.al (2019).

Applying mathematics laboratory simulation materials can enhance students' understanding of the concepts of systems of linear equations. This is indicated by an increase in the average student comprehension rate of concepts. Maryanti, I. (2021). Research by Lahcen et.al (2019) "Promoting proactive behavior through motivation: The case for asking for "math laboratory hours" reaffirms that it is very effective to request weekly laboratory hours in a college algebra course. It will also pave the way for the study of integrating dynamics into other lower-level math courses. There is no single research on laboratory methods in Pakistan at the school level in mathematics education (Nwoke, Bright & Ogoke, 2020).

Pragmatism applied to the problem of philosophical education improves philosophical education. This is done by deflating and clarifying the meaning of the problem and showing how to solve it. (Sharma, Devi, & Kumari, 2018), The theoretical underpinnings of practical learning are based on constructivism. It is cheered by the principle that learners can build their knowledge when there are sufficient opportunities for interaction, inquiry, or active participation in learning. Simamora, R. E., Sidabutar & Surya (2017). Knowledge construction occurs when learners establish their own concepts in the light of everyday life experiences. The experience takes place in a classroom environment in the context of various modes of education. According to constructivists, students construct their own concepts through previous knowledge, ideas, and activities encountered during learning (Boudourides, 2003).

Constructivist learning theory begins with four basic constructivist doctrines (epistemological foundations). The first doctrine focuses on the fact

that all knowledge is constructed from prior knowledge. This means that students need to apply and review during class. The second principle is focused on knowledge formation and basically, knowledge is constructed through social interaction (Thompson, 2013). The third principle stresses on social learning environment for knowledge construction (Coad, 2006; Goss et al., 2015). The last principle stresses that knowledge is developed in a context. This principle proposes activity-based learning which includes creative tasks in the form of assignments and projects for the students in mathematics (Jupri & Drijiver, 2016; Reid, 2010).

In mathematics classes, activities can be done by students by themselves or in the form of groups of students. In doing so, the learner often constructs new mathematical understandings (DeWolf et al., 2016; Palm et al., 2011; Radford, 2003). Several studies (Johansson, 2015; Mevarech & Kramarski, 2014; Schoenfeld, 1985) were done to assess the development of mathematical reasoning through meta-cognition. The application of pedagogical strategies for active learning in the classroom proves to be more beneficial when implemented on the basis of robust theoretical pedagogical models.

An active learning framework was developed following Kolb's (1984) experiential learning model. It provides a solid foundation for an active classroom learning framework. The four-step cycle of this model is very simple and effective, its simplicity and usability are the main reasons for its popularity (see diagram). It is an adjusted template for creating educational programs that practically engage learners in the learning process and provide an alternative to worn-out and ineffective traditional information delivery models. In a typical application, educators directly provide concrete experiential events. Conduct field trips, laboratory experiments, or role-plays and organize personal or group reflections on the experience (Kolb & Kolb, 2018)

In Pakistan, the quality of education is very low, and especially the quality of math education is too low. Therefore, it is necessary to apply new teaching methods to improve the quality and standard of education at the school level. The laboratory method is a combination of activity-based learning, problem-based learning, project-

based learning, cooperative learning, and more. Literature review shows that mathematics education is very important for students' cognitive development but unfortunately, in Pakistan, the situation is very different. Here in Pakistan mathematics education is facing many problems e.g. shortage of trained teachers and required facilities, large classes, workload, etc. This situation compels teachers to use traditional methods of teaching. The use of these traditional methods for teaching mathematics creates mathematics anxiety and mathematics avoidance among students. To overcome this problem, a learner-centered instructional approach with active learning instructional strategies is considered as most feasible. This instructional strategy minimizes mathematics anxiety and presents mathematics as the most interesting and useful subject for learners.

### Statement of the Problem

Poor Performance in Mathematics at the secondary school level Some of the key factors were a lack of mathematics laboratories and Mathematics teachers' unused laboratory techniques in teaching mathematics (Nwoke, Bright & Ogoke, 2020; Adewale Olanrewaju, Sunday & Anaduaka, Uche, 2021). Therefore this was designed to find out the practices and challenges regarding mathematics laboratories for Pedagogical Purposes in Punjab at the School Level” intends to identify the practice of mathematics laboratories at the Punjab school level. And to investigate the possible challenges to integrating the mathematics laboratory at the school level.

### Objective of the Study

1. To explore the practices of laboratories for pedagogical purposes in Punjab at the secondary school level.
2. To investigate the availability of tools and equipment related to mathematic activities for students at the Punjab secondary school level.
3. To explore the challenges for teachers to integrate mathematics laboratories for pedagogical purposes in Punjab at secondary schools.

### Research Questions

The following research questions guided the study.

1. To what extent does the availability of mathematics laboratories for pedagogical purposes in Punjab at the secondary school level?
2. To what extent are the mathematics learning-related materials and equipment available for students at the Punjab secondary school level?
3. What are the challenges for teachers to integrate mathematics laboratories for pedagogical purposes in Punjab secondary schools?

### Methodology

This study adopted the descriptive survey design to obtain data from mathematics teachers to examine teachers' perspectives towards the mathematics laboratory and its current practices and challenges regarding integration at the school level in Punjab. The main instrument used for data collection of the study was a questionnaire. The questionnaire used for the data collection was closed-ended. The questionnaire had three parts which cover three research questions. The items

on the questionnaire were scored as follows: Strongly Agree (5), Agree (4), Uncertain (3), Disagree (2), and Strongly Disagree. The questionnaire consisted of two main sections with the first being the biographic section and the second section soliciting the opinions of respondents for their school-related data. The descriptive survey research design was adopted in carrying out the study since it required the opinion of teachers on the availability and utilization of mathematics laboratory facilities for pedagogical purposes in secondary schools.

### Population and Sample Technique

The population of the study was made up of all secondary schools of District Chakwal. There was a total of 200 secondary schools from both male and female wings. The sampling technique for this study was a systematic random sample technique.

The systematic random sampling technique was a probability sampling method. In this technique, there was equal chance and randomization to select sample data that represents a population. The sample of the study consists of 60 schools which was 30 percent of the population. These schools were selected from their EMIS code number that was given on the official website of the Punjab Education Department. According to the systematic random sampling technique, every 3<sup>rd</sup> school was included in the sample.

The validity of the instrument was determined by two mathematics education experts and one measurement and evaluation expert, their expert judgments guided the restructuring of the instrument. To determine the reliability of the instrument, 5 copies were trial tested on teachers outside the study sample with the same characteristics and their responses gave a reliability coefficient of 0.76 determined using Cronbach's alpha formula. To administer the instrument, the researcher visited the selected schools and sought permission from the principals who directed the mathematics teachers. Method of data analysis The data collected were analyzed using mean and percentage with the help of SPSS software.

### Data Analysis and Results

There was a total of three main questions, and the overall picture gained from this information was now presented. The responses regarding practices and challenges are presented in the form of frequency and percentage.

Research question 1: To what extent does the availability of laboratories for pedagogical purposes in Punjab at the secondary school level?

In this part, there were seven statements, and each statement was answered yes or no by the respondents. The results of this part clearly show the frequency and percentage of each statement in the following table 1.

**Table 1**

*Availability of laboratories (n=60)*

Sr.no	Statement	Yes		No	
		Frequency	Percentage	Frequency	Percentage
1	The science laboratory is in working condition	44	73	16	27

Sr.no	Statement		Yes	No	
2	The computer laboratory is in working condition	47	78	13	22
3	The Mathematics laboratory is in working condition	4	06	56	94
4	Labs are fully equipped	11	18	49	82
5	There are extra periods for laboratory in a week for science and mathematics subjects.	8	13	52	87
6	There is enough furniture in the laboratory to fulfill the basic requirements of the lab.	13	21	47	79
7	Regular funds for the maintenance of the laboratory are provided	11	19	49	81
8	Mathematics activities related materials or kits are present in the science lab.	17	29	43	71

The results in Table 1 revealed that 73 percent of schools had science laboratories and 78 percent of schools had computer laboratories in working conditions. The results showed that only 6 percent of schools had mathematics laboratories which was a very shocking result. Those schools had laboratories that were not fully equipped only 18 percent disagreed with it. In 87 percent of schools, there were no extra periods for laboratory in a week for science and mathematics subjects. There was enough furniture in the laboratory to fulfill the basic requirements of the lab, but only 21 percent agreed with this statement. 81 percent of schools had no regular funds for the maintenance of the lab.

Mathematics activities related materials or kits were present in the science lab, 29 percent agreed and 71 disagreed with this statement.

Research question 2: To what extent were mathematic learning-related tools available for students in Punjab secondary schools?

In this part of the questionnaire, respondents asked about practices of mathematics laboratory facilities and tools available in your schools which utilized for pedagogical purposes. There were seven statements in this part and Table 2 shows a clear picture of the results.

**Table 2**

*Mathematics laboratory facilities (n=60)*

Sr.no	Statements	Frequency	Yes		No	
			Percentage	Frequency	Percentage	Percentage
1	Geometric shapes and solids (cubes, spheres, cones, cylinders, and pyramids)	27	45	33	55	
2	Geometric tools (rulers, protractors, compasses, and set squares)	38	63	22	37	
3	Graphing tools (graph paper, graphing calculators, X-Y coordinate boards, and overhead projectors)	07	12	53	88	
4	Manipulative tools (base-ten blocks, fraction bars, algebra tiles, pattern blocks, and counting beads.)	08	13	52	87	
5	Probability and statistics tools (dice, playing cards, spinners, random number generators, and data collection tools)	05	09	55	91	
6	Measurement instruments (measuring tapes, rulers, weighing scales, thermometers, and timers)	33	55	27	45	

Sr.no	Statements	Frequency	Yes	Frequency	No
			Percentage		Percentage
7	Activity kits (puzzles, games, flashcards, activitycards)	08	14	52	86

Table 2 revealed that 47 percent of schools had Geometric shapes and solids and 53 percent of schools had no such tools in schools. These shapes included cubes, spheres, cones, cylinders, and pyramids. Second statement about Geometric tools, 63 percent of schools had these shapes and tools in their schools. Graphing tools (graph paper, graphing calculators, X-Y coordinate boards, and overhead projectors), only 12 percent agreed that they had in their schools. 13 percent of schools agreed that they had Manipulative tools (base-ten blocks, fraction bars, algebra tiles, pattern blocks, and counting beads in schools. Most schools had

measurement tools in their schools and only 14 percent of schools had activity kits like puzzles, games, flashcards, and activity cards.

Research question 3: what are the challenges for teachers to integrate mathematics laboratories for pedagogical purposes in Punjab secondary schools?

In the last part of the questionnaire researcher explores the challenges regarding the integration of the mathematics lab. There were six statements in this part and a 5 Likert scale was used to know the opinion of respondents. The mean value of each statement was calculated with the help of SPSS.

**Table 3**  
challenges for integrating mathematic lab

Sr.no	Statement	Mean value
1	There was a spare room in your school to establish a mathematics lab.	3.2
2	There was enough material in the science laboratory to meet the requirements of students learning.	2.3
3	There was support from the school management to purchase lab-related equipment.	1.9
4	In your school any purchasing for laboratories in the last 5 years.	2.1
5	There were extra periods for the laboratory during the week.	1.7
6	The curriculum load did not allow me to do practical work formathematics subject.	4.2
7	There was a program from the government to establish amathematics laboratory in schools in the past.	1.2

The results of Table 3 revealed that most schools had spare rooms for establishing mathematics laboratories. The mean value of the first statement was 3.2. There was enough material in the science laboratory to meet the requirements of students learning, but most respondents disagreed with the statement. This result showed that laboratories were not fully equipped. Most respondents disagree that there was support from the school management to purchase lab-related equipment mean value was 1.9. Most schools did not purchase any laboratory equipment and apparatus in the last 5 years. Curriculum load impact to integrate laboratory in the mathematics subject, the mean value was 4.2 showing most teachers agreed with this statement.

**Discussion on Findings**

Most secondary schools of District Chakwal had science and computer laboratories but unfortunately, a few schools had mathematic laboratories separate from science and computer laboratories. In Pakistan mathematics education was very poor and problem solving skills of our students was very miserable. In the 21<sup>st</sup> century, our schools' education suffers such a crisis that 94 percent of secondary schools do not practical learning environment. Students learning of and performance in mathematics is affected by several factors, including students'

attitudes towards the subject, the teacher's instructional practices, and the school environment (Mazana et al., 2019).

- Results clear that our secondary school

infrastructure was very poor. Those schools had laboratories, but their condition was very miserable, with damaged furniture in the laboratory and no funds for regular maintenance. Most of the schools did not have a single period for the lab.

- Results of Table 2 revealed that most schools had geometrical shapes and measurement tools, but otherwise, they did not have mathematic kits and activity tools for students in their schools. Laboratory strategies are also activity-based education because the actual work in the laboratory is much the same as activity-based education. These techniques require laboratories equipped with mathematics-related equipment and other important teaching materials. For example, devices are associated with geometry, numerical models, charts, balances, various facts and figures made of wood or hardboard, chart paper, etc.
- Most secondary schools in Chakwal did not have extra room for mathematics laboratories. Those schools had spare rooms, their building condition was very poor. The result of this study heightened the big challenge was the lack of inadequate rooms in Chakwal secondary schools.
- The second challenge was the poor condition of laboratories especially the science laboratory was not properly maintained in most of the schools. There was not enough material in the science laboratory to meet the requirements of students learning. There was no support from the school management to purchase lab-related equipment. The shocking thing was that in the last 5 years, most schools have not purchased a single apparatus for the science lab.
- The results showed the third big challenge was no extra periods in the timetable for practical work in the laboratory during the week. Science subjects were taught in the classroom and only focused on theory work in science subjects. Practical work was the core of science subject in our education system. There was 25 percent of the marks in science subjects were for practical papers and if students failed in practical papers then he considered a full fail in

the subject. In our schools, practical papers were not considered in the timetable.

- Another challenge for integrating mathematic laboratories at the secondary school level was the curriculum load. The mathematics course was so lengthy that it was not allowed for mathematic teachers to do practical work in mathematics subjects.

### Conclusion

In conclusion, this study has revealed that there was no concept of a mathematics laboratory in our secondary schools. A few schools established mathematics laboratories with their effort but Govt. shows zero interest in establishing mathematics labs in schools. In gov. In secondary schools most schools had science and computer labs but the condition of the science laboratory was very miserable in the majority of schools, lack of furniture, outdated apparatus, and tools were not useable for the teaching and learning process. The majority of schools have no activity kits and geometrical shapes for the teaching and learning process. Teachers demanded the upgradation of laboratories but there was no support from gov. And school management. There were a lot of challenges in our education system but this study highlighted the poor attitude of Govt. and school management toward providing funds to upgrade the science laboratory and establish the mathematics lab.

### Recommendation

Based on the result of the study, it was recommended that;

1. The Government should provide funds for maintaining science laboratories and update these labs according to international standards.
2. Govt. should take the initiative to launch the program to establish mathematics laboratories in all secondary schools.
3. Mathematics teachers should work in synergy with school principals to purchase mathematic-related tools and activity kits for the improvement of mathematics education.
4. The school managers should include extra periods in the timetable for practical work in science and mathematics subjects.

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