

Experiences of Teachers and Students in Science Laboratories with Reference to Problems and Facilities: A Study of Secondary Schools (Peshawar)

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Abstract

The current study aimed to explore the experiences of teachers and students in science laboratories concerning problems and facilities at the secondary level in District Peshawar. Employing quantitative methodology, the study's objectives included exploring science teachers' experiences in conducting practical work and determining the learning experiences of science students in laboratories. Secondary school science teachers and grade 10th female science students constituted the sample. Eight teachers and 163 students were selected through a simple random sampling using the Rao soft online sampling calculator. Two self-structured questionnaires were used for data collection and frequency and percentage were used for the analysis. Results revealed that most schools need more basic laboratory facilities, including chemicals and apparatuses. Similarly, the support staff needed to be more sufficient. The study recommends that laboratories have all the required physical and human resources. Additionally, safety training for teachers and students may be provided.

Keywords: Science Laboratories; Experiences and Problems; Secondary Schools in Pakistan.

Introduction

The prime purpose of education is to help individuals acquire creative and critical thinking skills to become productive citizens. These higher-order thinking skills are linked with quality teaching in the classroom. In this framework, it can be rightly said that teaching is a demanding and complex responsibility that requires a specialized collection of skills, attitudes, and traits along with knowledge. It also requires adequate resources and proper utilization to promote students' learning (United Nations Education Scientific Cooperation (UNESCO, 2007). Teachers' role is pivotal in making students understand scientific theories through laboratory resources (Miller, 2011).

Practical work in science consists of core and related activities. Core activities include the content taught by the teachers in the classroom. The related or complementary activities usually occur in laboratories to improve the conceptual understanding of the subject matter. Therefore, practical work in laboratories is considered vital for science students. It has been acknowledged that quality practical work promotes students' interest and engagement in the lesson, which leads to effective learning [Science et al. Education (SCORE), 2008].

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The importance of teaching science to students of various levels in a developing country like Pakistan must be estimated (Bhutta & Rizvi, 2022). Its role in understanding the concepts of humans and the environment, global climate change, and even households is vital. Therefore, science teaching remained an essential part of Pakistan's secondary school curriculum in the late 1960s (Iqbal & Mahmood, 2000). According to a study conducted by faculty of the Aga Khan University, Institute for Educational Development, Pakistan (IED), on the status of science education, more than 90 percent of primary and lower-secondary students in Pakistan have only a poor or basic understanding of mathematics and science. The findings of the study also revealed the average science score as 34 out of 100 (Bhutta & Rizvi, 2022).

Similarly, studies by Ahmad (2018) and Hussain et al. (2019) concluded that science teachers in Pakistan usually aim to prepare students for exams and good grades. Their teaching strategies promote cramming and rote memorization. Students in such classrooms do not sustain interest. Likewise, Sheikh et al. (2013) argue that in Pakistani schools, examination means memorization of the content from the textbook. Students should be evaluated based on understanding or conceptual clarity.

Successful students in science can effectively demonstrate their knowledge in real-life situations (Tseng & Seidman, 2007). Luff (2018) suggested that teachers scaffold learning through modeling to enhance thinking and understanding. The low performance of students in chemistry, biology, and physics at the secondary level gives a dismal status to learning science in Pakistan. Buddha and Rizvi (2022) found that most public and private secondary school students are unsatisfied with learning science. For example, instruction in chemistry, physics, and biology in schools in the district of Peshawar should contribute more towards learning the fundamental knowledge and attitudes suggested in the policies. Therefore, making meaningful connections with the subject matter takes time for most students.

Literature Review

Malik et al. (2020) found that teachers and students are generally eager to engage in laboratory activities as part of science education. However, they face significant challenges, particularly the need for more available infrastructure. According to Simamra (2018), prior research has shown that secondary school laboratory activities must be more frequently implemented. A conducive environment in science is essential for learning and research purposes (Walter, 2009). Certain skills are needed to operate the lab effectively, which are essential for all sciences, including biology, chemistry, and physics. While every experiment proceeds through the scientific method, some need expensive instruments (Weingh, 2009).

Experts in different fields of science and technology have different requirements. For scientific research, the laboratory can be of different forms. A vacuum chamber or particle accelerator may be found in a physics lab. A biologist or chemist may use a science laboratory. Computers and sometimes supercomputers are used by computer scientists. Scientists in other fields use other kinds of laboratories (Lunetta, 2007). The primary aim of secondary school laboratories is to prepare students for higher education. A report by the National Education Association emphasized the significance of laboratory work in high school science in preparing students for college. In response, colleges began offering summer laboratory courses for teachers to address the demand for improved laboratory instruction in high schools (Atkin, 2007).

To get students ready for more science education, American teachers at the beginning focus on the theory and goals of science education. For secondary schools, Harvard professor Edwin Hall quickly starts using a list of forty physics experiments (Hall, 2009). The list outlined the

experiments, methods, and tools needed to complete all 40 experiments effectively for admission to Harvard University's physics program. Scientific supply companies sold complete equipment sets to schools, and passing these exercises became a requirement for enrolling in physics programs at other colleges and universities (Rudolph, 2005).

Modern science labs and equipment in schools and colleges are crucial for research, demonstrations, and lab studies (Rudolph, 2002). On the role of science laboratory, Farombi (1998) argued that "seeing is believing" is a strategy often used in teaching science-related subjects because students tend to understand and remember things better when they see them in action rather than just hearing about them. Therefore, laboratories are crucial for teaching science, and any science course's success greatly depends on having proper lab facilities. Labs provide an ideal setting for both active and cooperative learning (Hass, 2000). Hass stated that participating actively in lab exercises helps students better understand the concepts taught in lectures. Additionally, the laboratory experience can be improved further by encouraging students to collaborate and interact with each other during the practical activities.

Ensuring laboratory safety, which involves identifying potential hazards during procedures and activities, is essential. It is crucial to set up the lab to minimize risks and threats to everyone working there (Bayrak & Agaoglu, 2009). Science educators emphasize the importance of laboratory work, stating that scientific knowledge cannot be effectively learned solely from books. They argue that engaging in practical work helps students acquire knowledge and develop technical skills. Laboratory activities promote cognitive development and psychomotor skills while fostering a scientific attitude and enjoyment of science (Hofstein & Mamlok, 2007; Vincent & Lunetta, 2003). A secondary school is where students learn and grow, focusing on their needs and well-being (Blank et al., 2004). The focus of school labs depends on the goals of the school and the local area. Every school lab is different but aims to help students learn better. Different schools and even levels of government might have different ideas about how to use labs, but they all want to improve students' learning experiences (Nicaise, 2008).

Resource utilization is crucial for effective learning, involving factors like motivation, facilities, teaching resources, teaching skills, and curriculum demands. Labs provide opportunities for hands-on interaction with the material world, whether through experiments or simulations (Hegarty, 2009). Students' Laboratory experiences should reveal different aspects of scientific work, including reading, developing research questions, revising models, and presenting findings for discussion. However, most high schools offer limited lab activities, focusing mainly on data collection to support existing scientific theories (Lunetta, 2008). In Pakistani schools, sometimes labs are not used at all or need to be used better. There needs to be clear standards for using labs effectively in these schools.

Moreover, schools often lack good quality equipment and materials for financial reasons. Given this context, the present study was formulated to investigate the experiences and challenges encountered by both teachers and students during laboratory practical work. The study, therefore, aimed to achieve the following objectives:

1. To find out science teachers' experiences conducting practical work in laboratories in secondary schools in the Peshawar district.
2. To determine the learning experiences of science students in learning from practical work in laboratories in the said schools.
3. Examine the resources available in science laboratories and teachers' expertise in utilizing them.

Theoretical Framework

The present study was guided by John Dewey's constructivist learning theory, which states that people learn from their experiences (Dewey, 1938; Bruner, 1966). According to the theory, learning is a proactive and internal process of acquiring new ideas. It asserts that humans build their knowledge and understanding of the universe through personal experiences and observation. In order to acquire new knowledge, the learners must actively participate. They must translate the lessons the students have learned through practical experience. Students build their concepts and understanding through personal experiences (Millar, 2004). Looking at the nature of practical work in learning science, it can be inferred that students create their knowledge through personal involvement in laboratory work. In this way, they generate knowledge. The objective of the present study was to ascertain how students' learning experiences in laboratories contribute to the construction of their knowledge in the field of science within Pakistani classrooms.

Methodology

The current study was carried out using quantitative methodology. The quantitative method is the most established scientific approach (Saunders et al., 2009). Its use allows for replicated studies, enhancing their reliability and validity (Burns & Burns, 2008). The survey method was applied to explore the issue under research. A survey design in quantitative research is the process in which the researchers survey the entire or a representative population of people to determine the population's behavior, attitudes, characteristics, or opinions (Creswell, 2012). This method is appropriate when the population is large, and the objective is to examine issues related to society and human behavior. In the current study, the entire population consisted of government high schools in the district of Peshawar. Secondary School Teachers (SST) and 10th-grade science students from the selected schools participated in the research. Students of this level have sufficient classroom and laboratory experience (Anwar et al., 2020). Additionally, their coursework incorporates more practical work compared to the lower classes. Similarly, SST science teachers also have sufficient teaching and laboratory experience.

Students were selected through a stratified random sampling technique. Stratified random sampling is a highly reliable method applicable in various scenarios. With this technique, the sample size for each subgroup is proportional to the subgroup's share of the overall population. This technique involves dividing the target population into groups or strata based on specific attributes such as social class, gender, race, income, and educational background (Creswell, 2012). The schools were chosen using a simple random sampling method. Eight teachers, with two selected from each school, were also selected through a simple random sampling. The sample size 163 was determined using the Rao soft online sampling calculator.

Table 1: Sampling table

School	No of students	No of Teachers	Sample Size (stratified sampling)	No of Teachers (Random sampling)
School-1	70	4	40	2
School-2	65	5	38	2
School-3	72	3	43	2
School-4	73	3	42	2
Total	280	15	163	8

Content validation was done through the concerned subject and research experts, and their suggestions were incorporated. The value of Cronbach's alpha obtained was 0.74. The data were collected through two self-structured close-ended questionnaires based on a three-point Likert scale: Agree (A), Disagree (DA), and Undecided (UD). Separate questionnaires were used to collect data from students and teachers.

Findings and Discussion

The findings were categorized into two main themes: students' perceptions and experiences of learning from science practical's and teachers' experiences conducting practical work in science laboratories. A detailed account of the themes is presented below:

Students' Perceptions and Experiences

Most students shared that their school's science laboratory needs the necessary equipment, such as apparatus, models, and chemicals. This lack of resources is viewed as a hindrance to learning new concepts, which causes a poor understanding of science concepts. This poor understanding of concepts leads to incomplete tasks and poor learning. These findings correspond to Vincent and Lunetta (2003), who concluded that scientific knowledge cannot be effectively learned solely from books. They argued that engaging in practical work helps students acquire knowledge and develop technical skills. Laboratory activities promote cognitive development and psychomotor skills while fostering a scientific attitude and enjoyment of science. The present study's findings also revealed that students face difficulty sharing their results with teachers.

Students exhibit motivation for learning through practical work, regularly attending the laboratory sessions according to the scheduled timings outlined in the school timetable. Similarly, teachers diligently allocate the designated periods for laboratory sessions. Nevertheless, in certain schools, students requested their science teachers to conduct practical experiments more frequently. These findings support the findings of Nicaise (2008), who concluded that students must participate in experiments and constantly request their science teachers to conduct practical's to learn the concepts properly. This leads to completing tasks and getting better results.

Moreover, students also need guidance from teachers. Due to a lack of support in data analysis, students need help drawing meaningful conclusions from their experiments. Sometimes, students have difficulty following teachers' instructions during practical work. This absence of guidance has led to challenges for students, resulting in them needing to catch up in grasping the main concepts of the lesson.

Handling chemicals and other equipment in the laboratory is also fearful. Students fear possible mishaps and accidents, particularly in chemistry labs, as no safety measures exist. This fear distracted them from actively and confidently performing practical work in the laboratory. Bayrak and Agaoglu (2009) suggest that it is crucial to set up the lab to minimize risks and threats to everyone working there. However, students were familiar with operating specialized equipment in physics laboratories and found no technical difficulty with operating equipment in these laboratories. However, some instruments were found out of work.

Teachers' Experiences

Findings revealed that most teachers believed laboratories were well-equipped and updated and that all chemicals were properly managed. They planned to demonstrate practical work beforehand and encouraged students' participation in practical work. Regarding the availability of resources, teachers were found to be satisfied with laboratory resources. They disagreed with the idea that a

lack of sufficient laboratory resources affects students' interest in practical work and learning science subjects. Despite the lack of resources, students were motivated to conduct practical work in the laboratory. The majority of the classes were found to be large. However, teachers found it easy to handle large classes in the laboratory. However, they agreed that the laboratory environment did not support learning due to students' noise. According to teachers, students used to look for science practical's in revision papers. Conducting experiments requires an adequate amount of time.

The data revealed that teachers often needed more time allocated for practical work in the daily or weekly school timetable. They encountered difficulties in successfully managing practical tasks within the given time slot. Besides the inadequate time slot, most schools also needed a lab attendant and supportive staff. Managing the tasks of giving instructions, guiding students, and conducting experiments without supportive staff can be challenging for a single teacher. It was found that results could have been more reliable due to the low quality of chemicals, particularly in chemistry laboratories. Similarly, biology and physics teachers encountered the challenge of insufficient apparatus and models. The majority of schools were found to need more basic equipment.

Table 2: The table below shows findings on laboratory equipment

S#	Statement	DA	UD	A
1	Laboratory is well equipped.	94 (58%)	13 (8%)	56 (34.4%)
2	All equipment and reagents are updated.	89 (54.6%)	14 (8.6%)	60 (36.8%)
3	Essential equipment, reagent, chemicals are kept in proper place.	38 (23.3%)	2 (1.2%)	123 (75.5%)
4	Laboratory facilities are adequate in our school for conducting practical work.	36 (22.1%)	94 (57%)	116 (71.2%)
5	Safety measures are readily available.	98 (33.7%)	10 (6.1%)	55 (60.1%)

Conclusion

The present study aimed to determine the experiences of students and teachers in science laboratories concerning problems and facilities at secondary schools. Utilizing separate questionnaires for teachers and students, the study delved into determining how problems and issues faced by science students and teachers in conducting laboratory practical's affect their learning and teaching. According to the study findings, science laboratories lack proper resources and equipment. Similarly, proper setups were lacking, and reagents were not regularly updated. In most schools, lab attendants and support staff were also absent.

Moreover, the allocated time for conducting practical experiments in the school timetable was insufficient. Additionally, there were inadequate safety measures in the laboratories. As a result, students were afraid of using chemicals for experiments. This fear of accidents reduces their ability to focus on learning while conducting practical work. It shows that to give students greater confidence and focus in the lab, there is a need for more safety training and support improvement. The inadequacy of laboratory resources has a direct impact on students' grades. More practical exposure is needed to ensure they can effectively answer science questions. Similarly, a lack of

comprehension and guidance in data analysis often results in incomplete experiments. Students also need help handling equipment and chemicals, diminishing their overall learning experiences.

Recommendations

Based on the findings of the study, the following recommendations are suggested:

1. Keeping the laboratory well-equipped and resourceful is crucial to facilitate effective practical work and experimentation.
2. Proper training may be provided to teachers and students regarding laboratory safety concerns and the proper delivery of practical lessons.
3. School administration may ensure adequate time for teachers and students in school timetables for laboratory work to allow for thorough experimentation and learning.
4. Science teachers may be offered opportunities to receive in-service training to enhance their teaching skills and keep them updated with the latest developments in science education.
5. Teachers are supposed to maintain a conducive learning environment in the laboratory, promoting active engagement and effective learning among students.

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