

Students' Perception About Physics Laboratory Skills And Its Relation With Academic Achievement: Repercussion For Learning And Teaching

Dr. Tanveer Kouser¹, Dr. Rizwan Akram Rana², Dr. Amna Saeed³, Dr. Mahvish Ftima Kashif⁴

¹Assistant Professor, Department of Education, University of Lahore, Pakistan.

²Professor, Department of Education, University of Management and Technology.

³Assistant Professor, Institute of Education and Research, University of the Punjab, Pakistan.

⁴Assistant Professor, Faculty of Education, Lahore College for Women University, Lahore.

Abstract

This study was conducted to explore students' physics laboratory skills and its relations with academic achievements in various universities of Pakistan and also its repercussion for learning and teaching at university level. From Pakistan twenty universities 238 male and 258 female (total 496) students were selected by using convenient sampling techniques. The analysis showed that there was positive relationship in students' perception regarding physics laboratory skills as well as its relations with academic achievements. There was significant difference found in female and male students. A significant mean difference in female and male students' perception regarding physics laboratory skills and its relations with academic achievements.

Keywords: Students' laboratory Skills, academic achievement, Undergraduate students, Physics learning and teaching

Introduction

Understanding the world around us is critical, and Physics is the primary subject that can supply this knowledge. It aids in our ability to make connections between seemingly unrelated events and gives us a great instrument for original thought. Students who study physics get analytical and quantitative reasoning abilities as well as the ability to analyse data, which they can use to solve a wide range of problems in sectors as diverse as medicine, engineering, economics, and more. As a result, pupils must be eager to learn about the world around them. However, many students find physics to be a tedious and dry topic, and the theoretical and mathematical concepts are difficult to grasp. There is less opportunity for pupils to engage in hands-on activities and practical work as concepts get more complex and professors continue to teach theories and solve mathematical problems in the traditional manner. It is because of this that many students lose interest in learning physics and eventually give up on the subject altogether. Our society will suffer as a result of a lack of interest in such an essential topic (Elure, 2018). In part, it is because of this that innovative brains do not develop and as a result, new discoveries do not take place. With regards to Pakistan, which is a developing country that position in global innovation index is 88 as compared to Indian 45th, position, Turkey 53, Brazil 64 and many other countries in the region. Therefore, Pakistan is in dire need to increase the number of people who want to work in science and technology and to provide appropriate facilities in this regard to compete the world ([https://www.global_innovation_index.org /user_files/file/ report pdf/GII-2021](https://www.global_innovation_index.org/user_files/file/report_pdf/GII-2021)). Progress in science and technology cannot be made without a solid foundation in physics. For scientific students, science laboratories play a critical role in their education. These are the science laboratories that have advanced and scientifically purposed the planet. Many science researchers have suggested that when students are engaged in science laboratory for practical experiments, their learning and understanding levels improve (Hofstein and Lunetta, 2004; Tobin 1990; Hodson, 1993; Lazarowitz and Tamir, 1994; Lunetta 1998; Hofstein, 2004; Lunetta et al., 2007). The advanced countries have developed scientific knowledge, and they are presently inventing and discovering new horizons of advancement in science and technology.

Understanding basic science concepts as well as the development of laboratory abilities and science process skills are considered to be significant aims of science training at all levels. It has long been believed that the work done in the laboratory is essential for achieving these ends. It has been and continues to be a contentious issue among science educators (e.g. Woolnough and Allsop, 198;1.).

A central role was given to the laboratory in several 1960s science curriculum (e.g. PSSC, CHEM, BSCS, SCIS, SCISP, Nuffield) with focus on the process of science. As noted by Hodson (1988), curricular development in the past quarter century has seen a considerable change away from teaching science as a body of known

information toward science as a human activity, with an increasing focus on familiarity with the processes and procedures of science.

Science education is under scrutiny on several fronts, including its content as well as its pedagogy, as noted by Hofstein & Mamlok-Naaman (2007): New standards are emerging to help shape and revitalise science education (National Research Council, 1996; 2000). Furthermore, NRC's National Science Education Standards (1996) as well as the 2061 project (AAAS, 1990) emphasise the belief that scientific literacy can only be achieved via inquiry and practical activity in science education. Students' abilities and skills can be developed in inquiry-type laboratories, such as posing scientific questions, formulating hypotheses, designing and carrying out scientific investigations, formulating and revising scientific explanations, and communicating and defending scientific arguments (Krajcik et al., 2001; Hofstein et al., 2005). (See p. 1) Thousands of opportunities exist for the advancement of science education in developing countries. Many countries in the developing world are working hard. However, Pakistan's science education is in a terrible state, particularly at the secondary and collegiate levels. To begin with, schools have a dearth of supplies such as equipment, apparatus, and materials, as well as chemicals. The majority of science instructors are sluggish and unqualified to teach their fields. They have a lot of theoretical knowledge, but they lack the skill and competence to teach science in a professional manner compared to their counterparts in sophisticated nations. That's the best part of all: Science teachers do not use science labs with the available equipment, apparatus, and materials and chemicals. The usage of scientific laboratories is critical to the success of science education since the availability of resources has no value until they are put to use. According to Hanushek (2006), if resources are used inefficiently, the relationship between additional resources and outcomes becomes ambiguous. For this reason, a direct investigation of school outcomes and inputs is encouraged by this basic observation. For example (p. 4), Even though the government invests a lot of money in education, schools are given low-quality resources. Pakistan's educational standards are deteriorating across the board, but science education in particular is at an all-time low, thus it's imperative that the root causes of the current state of affairs be determined (Government of Pakistan, 2002). In our discussion of resource inputs around the world, the debate is broad in scope and narrow in focus when we emphasise the unequal influence of SRIs on Pakistani secondary school students' academic achievement.

Physics is abstract from a cognitive standpoint because it is composed of theories and concepts, including mathematical formulas. Students will be more engaged if the problem of abstraction is clarified. For better comprehension, abstract notions and theories need to be broken down into more manageable chunks of information. Experimentation can help clarify these minute details (Michellini, 2018). An experiment connects a world of theories with the world of experiences. Students create their knowledge as they witness the theories and concepts come to life through

experimentation. There are two modes of instruction: declarative, which uses logic to explain abstract concepts like rules, definitions, and laws, as well as procedural, which gives students hands-on experience to help them better grasp abstract concepts. In contrast to the declarative mode, the procedural mode makes concepts more concrete through experimenting; this is a synergistic relationship. Ideas and theories can be put into practise through experiments, allowing students to better understand the content (Elure,2018)So laboratories in higher education institutions equipped with modern facilities can play vital role in development of science and technology in Pakistan.

Review of Related Literature

Learning in a physics laboratory is essential, and professors must use it to educate their pupils. As a result, physics education is a major focus. Students' ability to analyse problems and develop conclusions is largely dependent on their level of laboratory proficiency. Hypotheses to test in the laboratory, observation and exact data recording are the abilities needed. Then the hypothesis can be accepted or rejected and the results communicated. Laboratory experiments assist students learn the principles and apply them to real-world situations, allowing them to have a better understanding of the world around them. These qualities are essential for scientific teachers in order to effectively teach science. As a result, future physic teachers should take the time to acquire these abilities, as their own lack of them can have a negative impact on students' ability to learn. To gauge a student's performance, it is crucial to use demonstrations and labs in the correct manner (2011). Thus, for teaching physics, in schools and in institutions for under-graduate students, laboratory work is thought to be basic component. Lunetta and Hofstein (2004) stated that the laboratory has dominant and fundamental part in teaching of science education and science educators claims that laboratory work helps to accumulate excellent knowledge. According to Millar (2004) practical work means “any learning work or teaching where students are involved in handling and observing materials and real objects.”

Physicists believe that pupils develop critical thinking, problem solving skills, and a profound comprehension of their subject matter. While it's easy to test students' knowledge, finding out if they think like physicists is more complicated. However, this is not the case, as students benefit greatly from practical experience gained through laboratory work (Madsen, McKagan, & Sayre, 2015).. The relevant knowledge emphasizes laboratory work in teaching of physics in undergraduate classes in the beginning of 20th century which be physics became more important later on. According to Sneddon, Hanif, Reid and Al-Ahmadi (2009) “physics education has distinguished characteristics of physics laboratory activities. It plays a main role in the learning and teaching of physics at school and undergraduate levels in the institutions”.

Laboratory work is an essential aspect of physics education at most colleges and institutions.

However, for the purpose of gaining a deeper understanding of a topic, laboratory research is sufficient. Rather than teaching physics principles, laboratory practise teaches laboratory skills. Data processing and error estimation are two of the most critical laboratory competencies to master. Furthermore, physicists must master the art of evaluating the validity of data.

For physicists, a natural surrounding for learning this skill is the laboratory where the data are produced., Read 1969; Nedelsky 1949; Menzie 1970; Boud 1973; Boud et al 1980; Trumper 2003 and Arons,1993 stated that many researchers have shown the importance of the laboratory activities from the outcome of their study and explained the reasons for this. They have disclosed many objectives, goals and aims for the laboratory work in schools and higher education. According to Bradley (2005) “practical activities involve didactic methods for practising all the concepts and learning, process and skills to enhance scientific knowledge”. Lunett and Hofstein(1982) and Tamir and Lazarowitz (1994) presented that laboratory work has the capability to improve positive social attitudes and relationships as well as intellectual growth. Sneddon, Hanif, Reid and Al-Ahmadi (2009) studied opinions, views and perceptions, about physics learning, of the students from the universities and concluded that undergraduate and he is not so easy as a legal assault physics laboratory activities may well be contributing factor in achieving set targets and creating enjoyment and interest in learning of physics education.

Student performance in chemistry may be affected by laboratory inadequacy according to Raimi (2002) and Adeyegbe (2005). As for the usage of laboratories, Farounbi (1998) asserted that pupils are better able to retain and comprehend what they see rather than hear. When students really use labs to educate and understand science, they are able to witness for themselves. Accurate laboratory conditions were found to improve students' performance in chemistry workshops, according to Adesoji and Olatunbosun (2008).

Various studies revealed positive relationship between practical work and academic achievement in learning physics education (Yang, & Heh, 2007; Pavešić, 2008; Sasmaz & Tatar, 2006; Sabry & Emuas, 1999; Nawaz, Mahmood, & Rana, 2004). In 1999 Emus and Sabry executed a research, in a science introductory course at university level, to find out the connection between laboratory experiments and academic achievements. They concluded that laboratory activities h affected e academic achievements. In 2002 Hirvonen & Viiri stated that “practical activities can aid to explore both process of learning and understanding of the contents of physics.”. Mahanani, Wening, Susanto, and Sudirman, (2020) have stated that to effectively engage in laboratory work is considered to involve students successfully in any real learning situation by applying real activities including problem solving, laboratory work and involvement with the natural situation. Popov and Vilaythong(2008) from the outcome of the study, carried out in Laos, revealed that majority of the students showed high regards of real work in physics education. Ergin and Aydogdu the (2008)

on the ground of their research established that “ As students become more proficient in science process, they become more academically successful.”.

The following research objectives were considered for this study:

1. To investigate in physics, at undergraduate level in Pakistan, students' laboratory work scores as well as academic achievement scores.
2. Establish in physics, at undergraduate level in Pakistan, the relationship between students' perception regarding the laboratory skills and academic achievement.
3. To find out in physics, at undergraduate level in Pakistan, the relationship between students' scores on perception about the laboratory expertise and laboratory activities.
4. To find out, in physics, students' laboratory activities and their perception of the contribution concerning skills in laboratory work on overall academic achievement scores in Physics.
5. Determine, in physics, the relationship between students' laboratory work scores, academic success scores and scores on perception regarding the laboratory skills.

He Research Methodology

The study was conducted on the students who worked in physics laboratory to study physics, therefore, causal comparative design was used. Causal comparative design is useful when it is difficult to conduct experiment and manipulate independent variable (Mills, & Gay, 2019).

Sample

To carry out this research a sample, from twenty selected universities from Pakistan, (Male=238 & Female= 258) total 496 students was chosen.

Research Instrument

An instrument consisting of demographic variables and 50 statements on a 6 point Likert scale type statement (from Never to Always) was applied to measure student perception about academic achievement, laboratory skills, and scores on laboratory skill course. Moreover, the instrument was divided into four sub-scales. These were; perception regarding teacher guidance (9 statements); Perception regarding investigative skills (6 statements); perception regarding open-endedness (27 statements); and perception regarding co-operation among students during laboratory work (8 statements).

Reliability of the perception about laboratory skills instrument was found to be 0.863 and it was determined by using Cronbach alpha reliability coefficient. The reliability coefficients for each of the four sub-scales were: perception regarding teacher

guidance (0.571); Perception regarding investigative skills (0.745); perception regarding open-endedness (0.749) and perception about co-operation in students during practical work (0.697).

Demographic Variables Information Proforma was developed by the researchers in order to gather data about demographic variables. It consisted of information regarding student's gender, university, semester, department, their scores on practical work in physics and overall academic achievement scores. (Scores achievement were confirmed by the officials of relevant departments).

Interpretation and Analysis of Data

Statistical techniques (Pearson r, linear regression and independent sample t test) were applied to analyse the data which was assembled from students of twenty chosen universities by the research investigators.

Table: 1 Relationship of students' laboratory activities, academic success and perception regarding laboratory skills

Aspects	N	Pearson r	Significance
Academic success & students' perception	496	0.848	.00
Academic success & physics laboratory skill	496	0.784	.00
Physics laboratory skill & students' perception	496	0.741	.00

Table 1 revealed that Pearson Correlation shows the $p \leq 0.05$ level of significance. There is a moderately to strong positive relationship exists between academic success and perception about Physics laboratory skills; academic achievement & physics laboratory skill and Physics laboratory skill & students' perception of undergraduate students.

These moderately to strong positive relationship leads to further data analysis and Regression analysis was carried out to establish the cause and effect relationship in students perceptions; their Physics laboratory skill and academic achievement.

Table: 2 Regression analysis regarding effect of perception of students on academic achievement in physics

Model	R-square	B	t-value	Significance
Perception of students and academic achievement in physics	0.722	0.017	35.68	0.00

Table 2 shows that perception of students regarding Laboratory skills have significant affect on academic achievement in physics as $p \leq 0.05$ level of significance.

Table: 3 Regression analysis regarding effect of perception on laboratory skill in physics

Model	R-square	B	t-value	Significance
Perception scores and laboratory work scores in physics	0.548	0.353	24.48	0.00

Table 3 depicts that perception of students regarding Laboratory skills have significant effect on laboratory work scores in physics as $p \leq 0.05$ level of significance.

The tables 2 and 3 revealed that at undergraduate level students' perception regarding their physics laboratory skills is a factor which contribute in students' achievement in physics. It shows that if appropriate facilities in the laboratory will be provided than students can perform better and further contribute in science and technology development in the country.

Independent sample t-test was applied to find out the difference in students' academic achievement and physics laboratory skill as well as students' perception regarding their physics laboratory skill at undergraduate level at universities and shows that mean of female students' academic achievement was pointedly better than male students at university level. However, there was no significant gender-wise difference in students' physics laboratory skills. T-test data is shown in table 5 and 6.

Table: 4 t-test for gender-wise difference on academic achievement, about laboratory skills.

Variable	Mean	df	t-value	sig
Female	3.1969	493	4.32	0.00
Male	3.0282			

Table: 5 Gender-wise difference calculated by t-test on practical skills and students' perception

Variable	Mean	df	t-value	sig
Female	79.550	49	.575	0.566
Male	78.960			

Table: 6 Gender-wise difference in students calculated by t-test for perception

Variable	Mean	df	t-value	sig
Female	197.209	493	0.412	0.68
Male	196.151			

Table 7 Relationship between perception regarding laboratory skills scale and its sub-scales and within sub-scales

Aspects	N	Pearson r	Significance
Perception regarding laboratory skills and Perception regarding investigative skills	496	0.689	.00
Perception regarding laboratory skills and scores on Perception regarding teacher guidance	496	0.729	.00
Perception regarding t laboratory skills and scores on Perception regarding co-operation in students during laboratory practical is very good feature regarding achievement in laboratory work by the undergraduate students in and Perception regarding laboratory skills and	496	0.722	.00
Perception regarding open-endedness	496	0.899	.00
Perception regarding investigative skill and Perception regarding teacher guidance	496	0.437	.00
Perception regarding investigative skill and Perception regarding co-operation in students during Laboratory work	496	0.430	.00
Perception regarding investigative skill and Perception regarding open-endedness	496	0.471	.00
Perception regarding teacher guidance and Perception regarding co-operation in students during laboratory work	496	0.428	.00
Perception regarding teacher guidance and Perception regarding open-endedness	496	0.521	.00
Perception regarding co-operation in students during Laboratory work and Perception about open-endedness	496	0.496	.00

Table 7 revealed that the range of relationship in students' perception on laboratory skills and its sub-scales as well as within sub-scales is slightly more positive to strongly positive. This consequently it's effect on the betterment of the country. It is crucial for science and technological advancement in Pakistan in the physics education.

Conclusion and Discussion

From the outcome of the research, it can be concluded that, in physics, there is a positive relationship between students' perception about practical skills and students' academic achievements. This is in alignment of previous studies. Dahar and Faize

(2011) reported that availability and the use of science laboratory has a positive relationship with science students' academic achievement. However, this study was not subject specific. Current study explored the relationship between students' perception about practical skills and students' academic achievements specifically in the subject of physics. Raimi (2002) reported that science laboratory has an effect on students' achievement in the course of chemistry. Adeyegbe (2005) also holds the view that laboratory sufficiency has capacity to affect the performance of students in the subject of chemistry. Shana and Abulibdeh (2020) reported that students who are taught using practical work in science courses has shown better achievement than those students who were taught using traditional method. Many more previous researches support current study's findings. Such as study conducted by Hofstein and Lunetta (1982) suggested that practical work in science course helps the students to learn better. Hofstein and Mamlok-Naaman (2007) also holds same view. It is also suggested that practical work motivates the students to learn (Hodson, 1990).

The current study has found that students' perceptions about practical skills related to laboratory has significant relationship with their achievement. Moreover, analysis of the data shows students' perception about their capability to execute experiments. Physics is science subject part of schools and universities and curriculum, and relatively differs from other non-science subjects- It's lessons are also taught in laboratories where both students and teachers involve to carry out demonstrations and practical activities. This method of teaching and learning of Physics forms it a practical subject. In science subjects, practical work is very useful including Physics because science concepts are more easily learnt and understood this way. Also, practical work stimulates in creating competence in methods and skills for scientific research activities.

The skills, attitudes and values, inherited to science including physics are valuable for students to adopt and develop them for their working life and for integrating in society for lifetime. Physics education aids to develop communicative skills and nurtures critical thinking. It strengthens social values in the society – physics research questions our own understanding and the environments around us. This methodically involves human values like fairness, integrity, diligence, curiosity, openness to new ideas, imagination and scepticism in the quest of answers to these questions. Science including physics lends itself to creative thinking which is characterised by flexibility, originality of ideas, fluency, imagination and courage. Physics requires students to solve problems and stimulates students' enquiring minds and curiosity. Physics is a practical subject and therefore promotes controlling, deductive, observational, and evaluative skills of the subject. It also fosters teamwork.

Recommendations for effective physics practical work:

- Students must be given opportunities to use materials and handle equipment while engaging collaboratively with others in environments in which they build up

scientific knowledge and participate, during the course of enquiry and investigation (Tobin, 1990, Kontro, Heino, Hendolin, Galambosi, 2018).

- Students must be made clear of intended results of the practical in order not to get them confused while carrying out complex practical work. (Mahanani, Wening, Susanto, & Sudirman, 2020).
- The practical work should be well-constructed, focus in-depth to assist students gain and advance science concepts or frameworks of concepts (Hofstein and Lunnetta, 2004).
- Students require to be allotted adequate time to interact, discuss and reflect in order to benefit learning from practical work (Gunstone and Champagne, 1990).
- Students are required to know how to take responsibilities of their learning and need to have opportunities for metacognitive activities (Madsen, McKagan, & Sayre, 2015).

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