PHYSICS PRACTICUM PREPARATION AND ASSESSMENT AT SECONDARY SCHOOL LEVEL: FACTS AND CHALLENGES

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Candidate of **Master of Philosophy** at the National University of Modern Languages do hereby declare that the thesis **"Physics Practicum Preparation And Assessment At Secondary School Level: Facts And Challenges"** submitted by me in partial fulfillment of M Phil degree, is my original work, and has not been submitted or published earlier. I also solemnly declare that it shall not, in future, be submitted by me for obtaining any other degree from this or any other university or institution.

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ABSTRACT

Title: Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

The study was designed to explore the facts and challenges regarding preparation and assessment of physics practicum at secondary level in Pakistan. The aim of research were (a) To explore that physics practicum at secondary level are according to standards and benchmarks set in national curriculum of physics 2006 (b) To find out the current practices regarding preparation of physics practicum assessment at secondary level in Pakistan. (c) To find out the current practices regarding assessment of physics practicum assessment at secondary level in Pakistan. (d) To investigate the problems and challenges faced by teachers during preparation and assessment of physics practicum. The study was descriptive in nature and survey method was used. The population of the study was teachers teaching physics at secondary level in F.G cantt and garrison institutes of Rawalpindi, Chaklala and Wha region. There are 83 schools in these three regions and 183 teachers are teaching physics teaching physics in these schools. A sample of 125 participants was selected by using purposive sampling technique. Data was collected from respondents through questionnaire. The questionnaire consists of 25 close ended questions and two open ended questions. The data was analyzed by mean score and data analysis. It appeared from the data that large class size, less allocated marks, less allocated time and inappropriate assessment practices are major barriers in implementation of Physics practicum according to true spirit of national curriculum of physics, 2006. Major recommendations are that class size may be reduced, marks weightage for Physics practicum may be increased, more time may be allocated for practicum and teachers may be trained for proper assessment.

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LIST OF ABBREVIATIONS

Abbreviation	Terms
UNESCO	United Nation Educational Scientific and Cultural Organization
SSC	Secondary School Certificate
NSTA	National Science Teachers Association
USA	United states of America
B.Sc	Bachelor of science
B.Ed	Bachelor in education
NTS	National Testing Service
IQ	Intelligence Quotient
CSPAR	The Class Size and Pupil Adult Ratio
GEM	Global Education Monitoring
GDP	Gross Domestic Product
STS	Science Technology Society
UK	United Kingdom
GPS	Global Positioning System
HEART	Health & Education Advice & Resource Team
AAPT	American Association of Physics Teachers
FBISE	Federal Board of Intermediate and Secondary Education
ISLE	Investigative science learning environment

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First of all I thank Almighty Allah, who is the most beneficent and the most merciful. Who sustains the springs of intellect and wisdom with the light of knowledge and guidance, and His Holy Prophet (Peace be upon Him) the ever greatest educator of mankind, who leads humanity to the path of light and everlasting success.

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Muhammad Imtiaz

DEDICATION

I dedicate this study to my beloved parents and my teachers as without their cooperation, help, appreciations and prayers it was quite impossible for me to complete this work.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Science education is study of natural world. Main aim of science is to enhance knowledge of a learner about natural world and develop its investigating skills. Science education is much more than fact based knowledge. Science education makes a learner capable to identify problems around him and to find their solution by using scientific knowledge. Science education is meaningless if learner did not find any connection between science and his daily life.

Science education is very important for developing countries like Pakistan because it play very important role in development. Pakistan needs to focus on science education. According to Rafaq Ali Akbar (2008) Pakistan needs scientists and technologists to address wide range of economical, geopolitical, social and environmental challenges in regional & global context. Pakistan is full of natural resources but due to dissatisfactory standard of science education Pakistan is not be able to utilize them and imports many things at the cast of valuable reserves. This put bad effect on its economy. Quality science education is very helpful in international job market. By improving standard of science education Pakistan can get access to international job market that can flourish its economy. The standard of its science education needs improvement. In past many researches have been conducted about different aspects of science education in Pakistan. Some of them are limited resources (Dahar & Faize, 2011, Kurshid 2008, Soomro 2009), Uncompetitive traditional teaching (Nazir & naqvi 2012, Sarwar & Hussain 2010) Corporal punishment

(Sarwar& Hussain, 2010) in effective pre and in-service training (Mehrunnisa 1998, Saeed 2007, UNESCO 2011-12) This research in a effort to raise the standard of science education in Pakistan.

Physics is very important branch of science and is nucleus of science and technology. Good education of Physics means good standard of science and technology. In Pakistan Physics curriculum at secondary level consist of two main components. “Theory” and “Practical” both components are important. Because theory gives knowledge and practical is helpful in understanding. Teachers mainly focus on theory paper and neglect practicum. According to research conducted by Osborne (2000) teachers prefer theory then practicum because of greater marks weight age for theory, less effort required for theory and lack of resources for practicum. Research conducted by Hunde and Tegegne also shows that practicum is overlooked by teachers**.** Practicum is very helpful in understanding of science education. It is considered a prominent feature of school science. Objectives of teaching of physics cannot be achieved without Physics practicum. According to Woolnough, 1991 many experts of education raise a question that whether at school level the practicum is effectively used or not?

Goals and objectives are basic part of a curriculum. These goals and objectives are standard set for teachers and students. Success of a teaching or learning activity is directly proportional to achievement of these goals and objectives. Faize (2011) in his research found that educational objectives of Physics cannot be achieves only by teaching theory to students. For achievement of educational objectives of Physics practicum is also necessary. A person having knowledge without understanding is similar to a person having car but he doesn’t know how to derive it. Practicum is heart of mastery in science discipline. Without practicum science knowledge is inert

(Muleta & Seid, 2010). In class rooms generally theory is taught by lecture method during which teacher is on driving seat while students have a very passive is role. But in laboratory student have opportunity to learn by doing. The can interacts with objects. This characteristic of practicum makes it very helpful in understanding of science. According to research work of Millar (2009) practicum is a learning activity in which students are involved in observing or manipulating objects for understanding. During practicum a student physically interact with objects, record his observation, manipulate data and then draw conclusion. In this way practicum is also helpful in extension of knowledge about natural world. If a teacher can show implementation of scientific concepts in laboratory this might minimize the room of memorization in Physics and also contribute in development of higher order thinking of students. Practicum encourages students to think independently during an investigation which improve students' performance. Same as research study indicated that there is a very strong relation between use of laboratory and student performance in examination of science subjects (Mulela, 2015). When students see practical demonstration of a concept it not only helps them in better understanding but also makes their concept more concrete. In addition to this, it is not wrong to say that through quality practicum a teacher can attract students towards studies because class room lectures are boring as compared to laboratory classes. The laboratories are the platform for young students where they got opportunities to enhance their creative thinking and problem-solving abilities. Practicum makes a student capable to generate more scientific knowledge. Practicum helps a student to find the answer of two questions that is "what" and "how" and these two questions are also the foundation of science. The answer of these questions helps a student to understand mysteries around him. Only memorization of some definitions and mathematical equations are not

sufficient to achieve the answer of these questions. For the answers of what and how deep understanding of scientific concepts is required. Practicum is very helpful in developing the understanding and investigating skills of a student. It is also helpful for a student to remember different ideas.

Secondary level is very important stage in our education system. It is transition stage from general science to discipline based curriculum. It is very important that learner should be given sufficient understanding of the subject so that they become capable to meet academic challenges in subject at higher level. In addition to this, a research study indicates that because of this inappropriate understanding of scientific concepts many students after secondary level switched from science discipline to humanities and commerce. The standard of science education in Pakistan is bad enough to scare students away (A.H Nayyar, 2020).Due to this low standard our students are conceptually not good. It is common observation that we are not getting good product after secondary school examination. Moreover, students in our education system are getting degrees in science disciplines without having any deep understanding of the scientific concepts and firm grip on practicum. For example, a Physics student after passing SSC examination has insufficient understanding about practicum and there are many reasons for this less effectiveness of Physics Practicum.

1.2 Rational of the Study

Practicum is very important part of physics curriculum. Mastery in physics is not possible without mastery in Physics practicum. Unluckily in Pakistan standard of Physics practicum is not satisfactory. Students are not capable to apply the knowledge they get from text books in real life. Theoretically they are good but practically not. This study will help to diagnose the Physics practicum at secondary level in Pakistan

and to find problems and issues related to it. Findings of this study will raise the standard of Physics education in Pakistan.

Many researches have been carried about Physics practicum. Some researches are about analysis of Physics curriculum at secondary level, some are about role of Physics practicum in science education while some are about availability of physical infrastructure and apparatus. No research has been carried about implementation of Physics practicum according to our national policy. The research is quite unique. This research is about implementation of Physics practicum at secondary level according to standard and benchmarks set in national curriculum of physics 2006.In this research barriers for proper implementation of Physics practicum at secondary level were also investigated .

1.3 The Statement of Problem

After independence Pakistan has made improvement in the field of science education. But still there is much to achieve especially in the field of practicum. Many researches have been made about practicum to diagnose it. Some important researches about practicum are mentioned under.

Parveen and Iqbal (2012) have made a research about over crowded class room. They write in the findings of their research that due to large teacher-student ratio teachers face many problems in Physics laboratories and cannot teach properly. Naeem (2015) have made a research about physical conditions of Physics laboratories and found that physical conditions of Physics laboratories in schools are not as per required standard so is a barrier in proper practicum work. Ashraf and Iqra (2016) made a research about practicum and found that poor monitoring, inappropriate importance and insufficient budget is negatively affecting practicum in Physics laboratories. (Abebe Adugna Chala (2019) argued in his research that ineffective

implementation of practicum has very bad effect on student's performance.

Since present era belong to science and technology. This fact has increased the quantum of Physics practicum more. The secondary level of education is very important level in our education system. This level is considered as base for higher education. Next level of education in our system is higher secondary level. At higher secondary level a student have to select a field for his carrier. It is therefore very important that these issues of practicum at secondary level must be addressed. Because these issues of Physics practicum deprive students from deep and clear understanding of basic concepts of Physics. So that good quality education must be ensured. If there are deficiencies in education at secondary level then these deficiencies will affect the academic performance in future. We have National Curriculum for Physics 2006 (Grades IX-X). In this document standards and benchmarks are set. We are not achieving these bench marks and standards. There are many reasons for this. Therefore, it is very important to investigate about problems and issues related to practicum at secondary level.

The problem under investigation is to evaluate preparation and assessment of Physics practicum at secondary school level and to find facts and challenges related to it.

1.4 Research Objectives

1. To explore Physics practicum at secondary level according to standards and benchmarks set in national curriculum of physics 2006.
2. To find out the current practices regarding preparation of Physics practicum assessment at secondary level.
3. To find out the current practices regarding assessment of Physics practicum assessment at secondary level.

4. To investigate the problems and challenges faced by teachers during preparation and assessment of Physics practicum.

1.5 Research Questions

1. To what extent Physics practicum meets the standards and benchmarks set in National Curriculum of physics 2006?
2. What are the current practices regarding preparation of Physics practicum at secondary level in Pakistan?
3. What are the current practices regarding assessment of Physics practicum at secondary level in Pakistan?
4. What are the challenges faced by teachers during Physics practicum in secondary school of Pakistan?

1.6 Theoretical Frame Work

National Curriculum for Physics (Grades IX-X) 2006 developed by ministry of education, government of Pakistan is the theoretical frame work for his research. It is stated in National curriculum for physics (Grades IX –X) that main aim of teaching of physics at secondary level is to promote process-investigation skills, problem-solving abilities and application of concepts useful in real life situations.

When a curriculum is designed some standards are also set. These standards are set to make teaching learning activity more efficient. Standards tell us what knowledge student should gain and what ability he should gain at the end of course. Standards are lighthouse for teachers. Some main standards set in Physics curriculum (Grades IX-X) are

(a) Student will be able to use scientific knowledge to identify problems around them and to find their solutions in systematic and organized way (b) Student will be able to understand scientific investigation they will be able to design and conduct

experiment and communicate their findings using conventional and technological tools(c) Students will have a clear understanding about basic concepts of matter and energy, their interaction.

Achievement of these objects means successful implementation of physics practicum. If these objectives are not achieved then this mean there are some issues in implementation of practical work.

In National Curriculum for Physics (Grades IX-X) 2006 some bench marks are also set. Bench marks are indicators to measure the performance of anything. These benchmarks are very helpful to find effectiveness of teaching. In this research we will find out that up to which level these benchmarks have been achieved. According to these benchmarks a student after secondary level should generate scientific questions about his surrounding on the basis of his observations. National Curriculum for Physics (Grades IX-X) 2006 also believes that after passing secondary level can use equipment for scientific investigation effectively.

National Curriculum of Physics is a very comprehensive document. Formation team for this curriculum comprises of senior teachers of public and private schools, subject specialist of Punjab text board, senior member of Curriculum Research & Development centre, members of provincial institute of teacher education During its formation comparative studied of best curricula of the world was carried out. Among these curricula were Physics GCE O Level 2007, NBSE Physics Curriculum of India, Physics Curriculum Guidelines of Ontario, Canada and Grades Nine Through twelve-Physics. California State Board of Education, U.S.A.

One very important feature of this document is that it contains the standards. Standards are the level that students must achieve. In simple words standards are the target set for teachers and students. These standards are very help full for teachers.

Achievement of these standards means achievement of target.

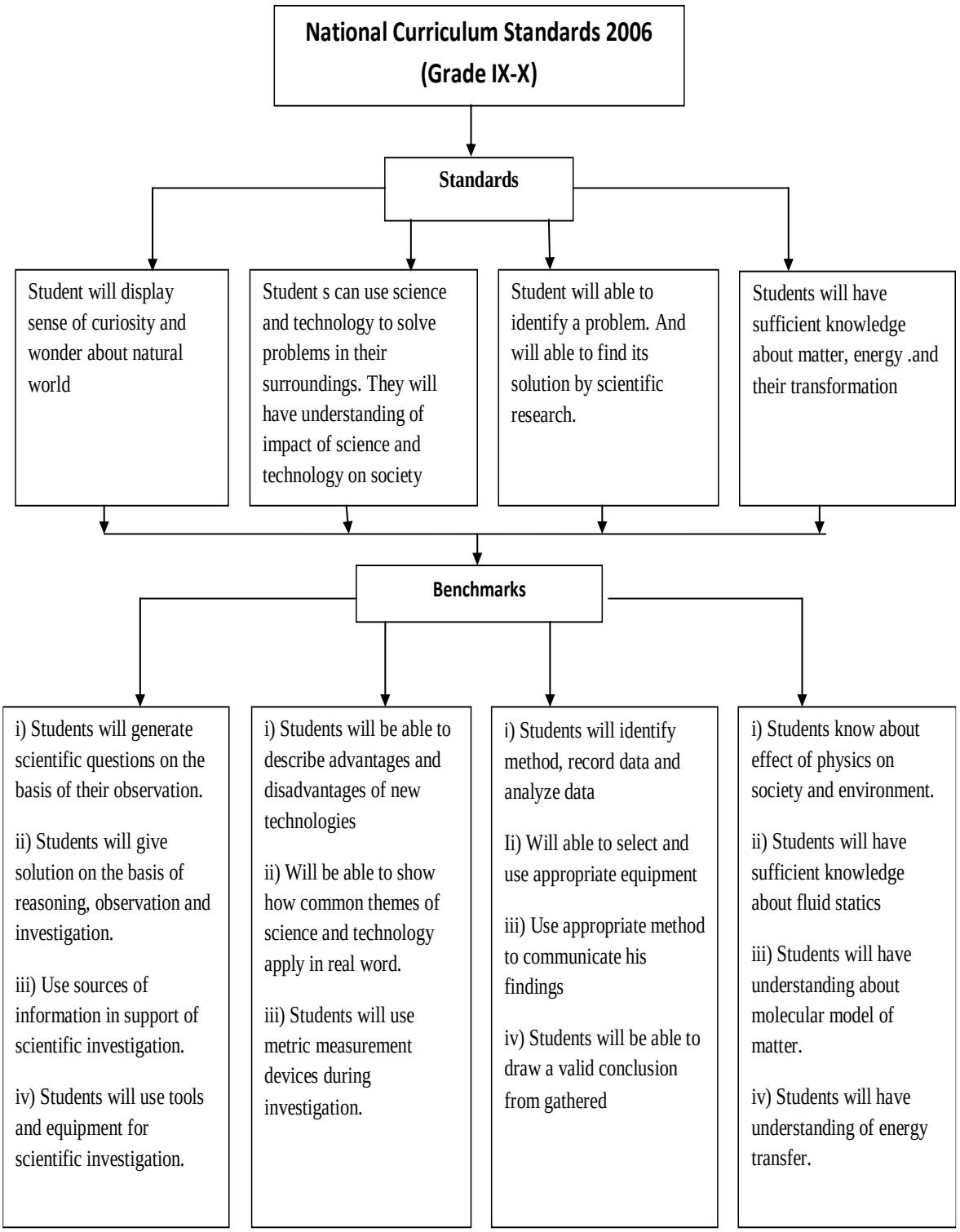

Figure 1.1 National curriculum of Physics SSC 2006. (National curriculum of physics. 2006)

1.7 Conceptual Framework of the Study.

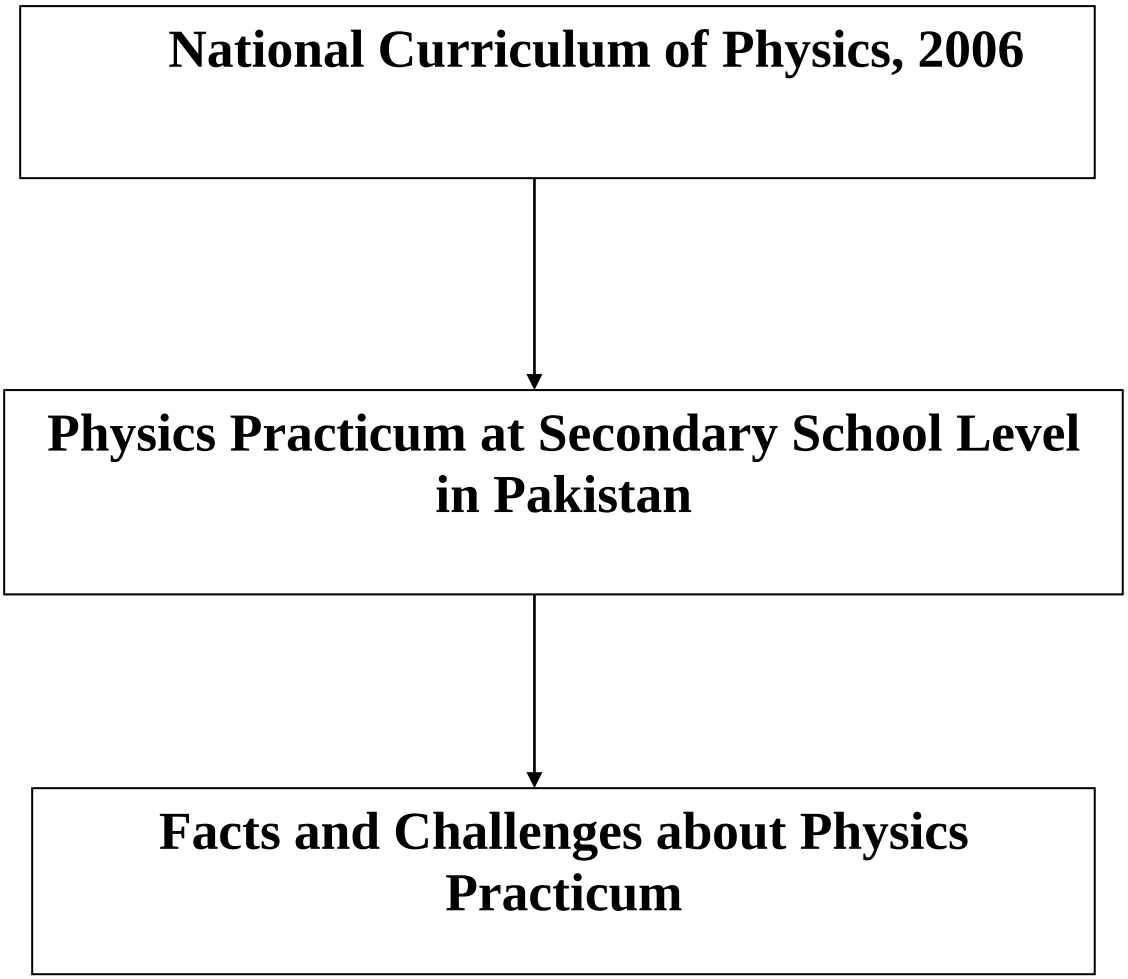

Figure1.2: Conceptual framework of the study

1.8 Significance of the Study

The result of study may help Physics teachers, school heads and officers of education departments. This study may highlight importance of Physics practicum and make them to think about standard of Physics practicum at secondary level. This study will highlight the facts about Physics practicum. It will help to increase the effectiveness of practicum.

This research will divert the attention of other researchers toward assessment of Physics practicum according to these standards and benchmarks set in National Curriculum of Physics 2006. This research may also draw the attention of researcher's towards National Curriculum standards 2006 which may lead further improvement in this document.

The findings of the research may be helpful for curriculum developers and text book writers in uplifting the standard of practicum at secondary level.

This study will also motivate researchers to investigate about practicum in other disciplines of science like Chemistry, Biology etc. This will be beneficial for these disciplines of science. Because practicum is equally important in these disciplines as it is in Physics. In this way this research will be beneficial for other science disciplines. This research will produce very valuable literature for researcher of science education.

Many students drop science subjects after secondary level and select subject of Humanities. They feel difficulties in science subjects. Many students argued they find no connections between what they have been taught in class and what they encounter in everyday life (Hussain and Reid 2006**).** This dropping rate of students can be reduced by improving standard of science education. This research may be helpful in improving standard of science education.

1.9 Research Methodology

This research is descriptive and survey method was used.

1.10 Research Design

This study is quantitative in nature. Data was collected through research questionnaire from 125 Physics teachers of Federal Government Cantt and Garrison schools.

1.11 Population

All Physics teachers teaching in F.G cantt & Garrison secondary schools of Rawalpindi, Chaklala and Wha regions are the population of the study. There are 83 schools in these three regions and 183 teachers are teaching physics at secondary level at these schools.

1.12 Sampling Technique

During a research an investigation of a large population is very difficult. So a sample is extracted from population. In this research purposive sampling technique was used for extraction of sample from population. Here 125 teachers were selected as sample from 183 teachers of the population.

1.13 Research Instrument

In this research data is collected by self administered questionnaire with the frame work of National Curriculum of Physics, 2006. The questionnaire was developed by researcher after review of related literature. The questionnaire was designed to collect data from Physics teachers.The validity and reliability of questionnaire was developed with the help of experts and pilot testing. On the advice of experts and suggestions made by respondents of pilot testing some minor changes were made in questionnaire to make it more compatible. The questionnaire consists of

twenty five closed ended questions and two open ended questions.

1.14 Data Collection

After establishing validity and reliability of questionnaire researcher started process of data collection. At first step researcher got permission letter for data collection from his department. At second step researcher personally visited to the respondents. At third step researcher thoroughly explained them objectives of research and requested them for filling up the questionnaire. In some cases where personal visit was very difficult questionnaires were mailed to respondents. These respondents were also contacted on phone and were explained about the purpose of research.

1.15 Delimitations

This study was delimited only for subject of Physics. Only practicum of secondary level was investigated. Data was collected only from teachers of Federal Government Institutions teaching (Cantt /Garrison) of Rawalpindi, Chaklala and Wah regions.

1.16 Operational Definitions

1.16.1 Physics. Physics is one of the distinct disciplines of physical sciences. In Physics we study about matter, energy and their interaction.

1.16.2 Practicum. Practicum is an activity in which students physically interact with objects around them in order to gather information about these objects. Research tools, data collection techniques and science theories are often use in practicum. Practicum is not only helpful in understanding of natural world but also enhanced remembering.

1.16.3 Assessment. Assessment refers to all those methods and techniques that are use to determine the knowledge and skills that students have gained at the end

of a learning activity. Assessments are also carried out to find the gap between what have been learned and what was indented to learn.

1.16.4 Facts. A Piece of information based on reality. Fact is something that actually exists and is considered as true information. Facts are important because decisions are made on the base of these facts.

1.16.5 Challenges. A challenge is something that tests you. Challenge means barriers in achieving a target. The quantum of challenge tells about efforts required in achieving a target.

CHAPTER 2

Review of Related Literature

This chapter provides a brief review of studies about Physics practicum. This chapter not only gives a concise definition of Physics practicum but also highlight common goals of Physics practicum. Different issues related to preparation and assessments of Physics practicum at secondary level find in previous studies are mentioned in this chapter. This chapter thoroughly highlight standard and bench marks set in national curriculum of Physics 2006. This chapter provide a strong rational for Physics practicum at secondary level and highlight the consequences of inappropriate standard of practicum at secondary level.

2.1 Concept and Rational of Practicum in Science Education

The science course at secondary level in Pakistan consists of two components, Theory and practicum. For practicum students go in laboratory under the supervision of their teacher. Practicum is very important part of science curriculum because it is help full in understanding and acquisition of certain skills. Objectives of science education cannot be achieved without practicum. Educationists have defined practicum in different ways. These definitions are very help full in understanding nature and importance of practicum.

Lunetta el al. (2007) define practicum as those activities in which students interact with objects or with secondary sources of data to develop their understanding.

According to Alsop & Watts (2003) practicum is interaction of thinking and doing and is a key to make science learning more effective.

Abrahams & Millar (2008) states that practicum is not only helpful in communicating information about natural world but also for developing understanding and scientific approach of students.

Practicum is defined as the activities in which students directly interact with natural world and gathered information using theories of science. (WRC, 2006)

Above definitions highlights the role of practicum in learning. Learning science without practicum is like reading literature without reading books. For proper learning and teaching of science, laboratory must be an integral part of science curriculum (NSTA, 2006). If a student has knowledge about scientific concepts but he is not skill full to use his knowledge then such knowledge is not beneficial for him or his society. By practicum students verify existing knowledge and make efforts for new knowledge. Practicum is very essential component of science education (Mafunika, 2006). Practicum plays very important role in teaching and learning of science education. It gives an insight of scientific knowledge and helpful in acquiring certain scientific skills. For social and economic development all countries of the world should make efforts to improve the standard of their science education. Many factors are involved in improvement of science education, practicum in one of them (UNESCO,1996). Practicum provides learners an opportunity to develop manipulative skills and investigative skills (Mustapha 2002). Practicum is not only help full in skill development it also develops understanding about natural world. Practical teaching is better than theoretical teaching (Lazarowitz & Tamir, 1994), According to Shulman & Tahir (1973) complexity of subject matter of science, spirit of scientific method, interesting nature of practicum work are three rational for practicum of physics

Fast communication resources, excellent health facilities, cheaper and environment friendly energy resources all are the blessing of hard work of physicist in laboratory. This means quality practicum brings prosperity for humanity. Can America claim as a super power without nuclear technology?

Advancement in science and technology has increased the demand of science

graduates in world. Millions of jobs have been created in Europe, Middle East, U.K, Australia, and America by excellence in science education our students can avail these job opportunities. The excellence in science education cannot be achieved by quality practicum in laboratory.

2.2 Physics practicum: Historical and Philosophical Aspects

(a) It was the mid of 16th century when research methodology in science make a shift from Aristotelian reasoning style to Galileo Galile experimental style. The reason for this shift was marvelous experimental work of Galilo and Farancis Bacon. Galileo by using experimental techniques successfully explain motion of freely falling bodies, motion of simple pendulum, and motion of a projectile. During same era Francis Bacon produced a wonderful book “Novum Organum “In this book scientific method based on experimental approach was discussed in details. Two important features of this scientific method were ‘gradual induction’ and ‘exclusion’. Main components of this scientific model are shown in figure 2 (Gurinder singh, 2014)

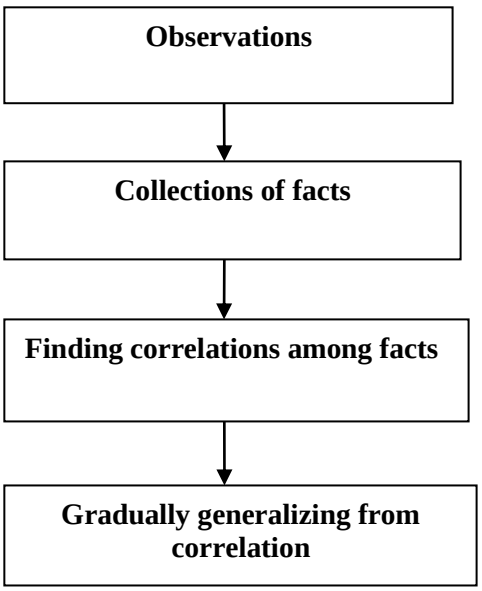

Figure 2.1: Scientific method presented by Francis Bacon (Gurinder singh, 2014)

Galileo argues in support of experimental approach that only qualitative explanation is not sufficient for explanation of a phenomenon. He said that quantitative explanation is also necessary for explanation of a phenomenon.

(b) During 17^{th} century experimental method was at its peak. Robert Boyle, Robert Hook, Isaac Newton performed very important experiment in laboratories. These experiments further divert research in science towards experimental approach. With the passage of time laboratories start becoming part of colleges and universities.

(c) During first half of 19^{th} centuries their science laboratories were setup in many colleges and universities across Britain. But most of them were for Chemistry. During the last quarter of 19^{th} century Physics laboratory was also set up in educational institutes (Jekins, 2002). At the end of 19^{th} century laboratory become an integral part of science curriculum not only in Britain but also in USA. In those laboratories most of the experimental work was of verifying nature. Already performed experiments were demonstrated to the students.

(d) With the start of 20^{th} century a school of thought emerges according to which improvements are required in practicum. Armstrong was among leading educationist from this school of thought. He declared the traditional instructive method of science as didactic. He argued that every student is capable to innovate. He said that students should not be told concepts they should be made to discover concepts. According to Armstrong's views a student should be trained as a little scientist. John Dewy was also from this school of thought (Singh, G. 2014). According to him most of the science material is presented as readymade material to the students with no thinking is involved. According to John Dewy scientific research method should encompasses body of knowledge and process by which something become knowledge. Dewy stressed that practicum should not be a recipe. Main

concern by Armstrong and dewy was instructional teaching in laboratory must be replaced by practical teaching because traditional teaching practices are not fulfilling the demands of science. These efforts made experiment approach dominant. Armstrong's heuristic method brings some changes in laboratory work during early 20th century. During the first half of 20th century experiment approach was followed in laboratories. The pattern of this experiment approach is shown in figure 3. (Gurinder singh, 2014)

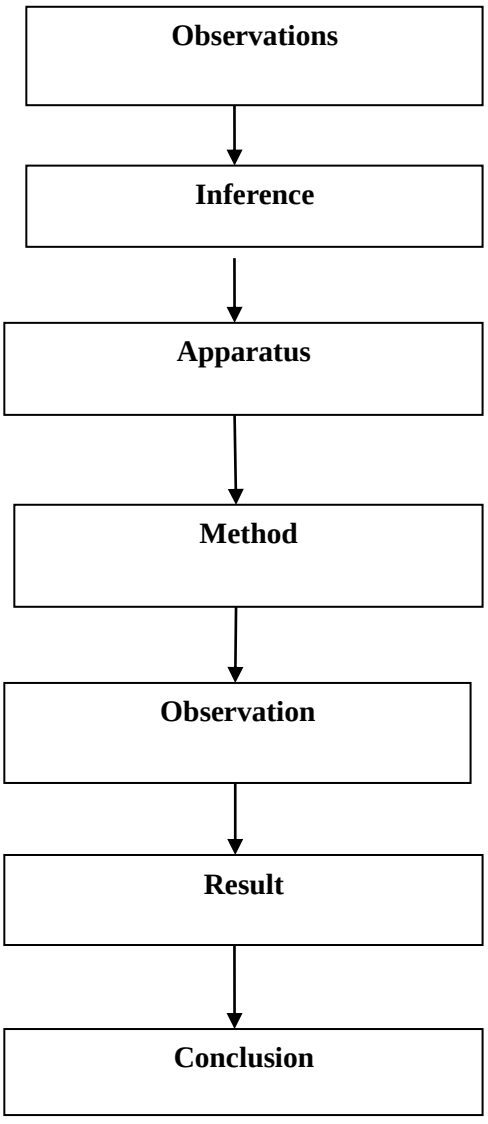

Figure 2.2: Main steps of experimental approach (Gurinder singh, 2014)

During start of second half of 20th century an inquiry-based curriculum was introduced in USA and England. According to this curriculum a student should be engaged in investigation. He must be helped in discovery of new concepts rather giving him concept directly. This inquiry-based curriculum has its roots from inductive philosophy of science (Singh, G. 2014).Under the umbrella of inquiry-based curriculum practical work has become an essential component of science curriculum. But soon educationists start criticizing inquiry-based curriculum. They argued that in this approach practical work is limited to acquisition of certain skills and the practical work is not as effective as it is supposed. At the end of 20th century a hypothetico-deductive approach replaced inquiry approach. This approach suggests that students should form their hypothesis, design experiment to test their hypothesis and draw conclusions from experiments.

2.3 Physics Practicum: Goals and Objectives

There are number of goals of Physics practicum most of them are also goals of science education (Lunetta, 1998) Goals and objectives are base of a teaching learning activity. Clear goals and objectives clarify what is to be accomplished. The practicum has become part of school curriculum in the last quarter of 19th century. Since then the goals of practicum have been changed with passage of times. Initially the focus of practical was to introduce students with concepts. Laboratories were used to verify discovered phenomenon. The goals of practicum were related to understanding of scientific concepts. With the implementation of inquiry approach focus was shift practical skills. That modified goals of practicum too. At the end of 20th century hypothetico-deductive approach takes over inquiry approach. New goals were formed. According to hypothetico-deductive practical work set up a link between practicum skills and prior concepts.

According to National Curriculum of Physics (IX-X) following are the goals of Physics practicum (National curriculum of Physics, 2006)

i. Develop sensitivity about nature
ii. Develop curiosity about nature
iii. A student must have understanding about natural world
iv. Select and use suitable apparatus for conducting an experiment
v. Evaluate strength and weakness of data
vi. Draw a valid conclusion from gathered data

The National Research Council (NSR) of the national Academies U.S.A has defined following goals of Physics practicum

i. Develop mastery of relevant subject.
ii. Develop scientific reasoning.
iii. Understanding of complex scientific work
iv. Understanding about nature
v. Create interest about learning of science
vi. Develop a habit of collaborative efforts(Singh, G. 2014)

The national council for educational research and training in India has defined following objective for Physics practicum at secondary level

i. To produce objectivity cooperative attitude in students
ii. To make them logical thinker
iii. To produce observational skills in them
iv. To produce procedural skills in them
v. To inculcate manipulative skills in them

vi. To inculcate drawing skills in them. (Singh, G. 2014)

According to The National Academics of Science Engineering and Medicines, U.S.A main goals of Physics practicum at school level are

i. To produce individuals that can understand and evaluate gathered information and can make appropriate decisions
ii. To develop basic knowledge about science
iii. To develop basic skills in students that can be help full in generation of new knowledge.
iv. Develop in students' habit of mind that will help them to understand subject more deeply in higher classes(Singh, G. 2014)

The American Association of Physics Teacher (AAPT) has defined five goals for Physics practicum at secondary level (Singh, G. 2014). These goals are

i. Designing of an experiment Students should learn how to design an experiment.
ii. Analytical skills: he should learn how to analyze qualitative as well as quantitative data
iii. Conceptual learning: Basic concepts should be clear to student
iv. Learning with understanding: Students should have understanding about basic concepts of physics
v. Development of collaborative learning skills: Make students capable of working in groups and develop a attitude of cooperation with other group members.

If we go through the goals and objectives formed by the various bodies we will find they belong to some broader categories. If we group the in categories we will get following main categories

i. Motivation, Interest
ii. Understanding of scientific concepts
iii. Designing skills for experimentation
iv. Analyzing of data
v. Scientific attitude of apparatus

So we can say that above mentioned goals are commonly accepted goals for Physics practicum. These goals are target of physics teachers and student during Physics practicum. If these goals are achieved during practical work then this mean that practical work is performed satisfactorily otherwise there are some issues in proper implementation of Physics practicum.

2.4 Critical Analysis of Physics practicum

Success of a teaching or learning activity is directly proportional to achievement of these goals and objectives (Singh, G. 2014) In Pakistan different goals and objectives have been set for Physics practicum at secondary level. These goals and objectives are part of National Curriculum of physics (IX X) 2006. According to National Curriculum of Physics (IX-X) following are the goals of Physics practicum

i. Develop sensitivity about nature
ii. Develop curiosity about nature
iii. Students have understanding of world around him.
iv. Students can design and perform an experiment.
v. Students can analyze data. (2006)

Science educators raised many questions about these goals and objectives of practical work. Some of them are

i. Are these goals actually achieved?
ii. Are these goals meets with learning outcomes?

iii. Do the resources spend on laboratory work result into some meaning full learning?

The answers of these questions are very important**.** Because these goals are the foundation of the science education (Singh, G. 2014)

Physics practicum performed in school laboratories is not very productive (Hodson, 1990). According to Hodson the claim by educationists that Physics practicum is very motivating and interesting is not based on solid grounds. He argued that how all students con not be motivated by doing same things? Students of secondary level can be motivated by giving them a challenging task or a chance to manipulate by interaction with objects. But in school laboratories there is no such activity. Similarly, Monk and Osborne (2010) argued that student can be motivated by practicum if they are given independence in practicum. In our laboratories there is no independence for students. They have to fallow a recipe. Hodson also rejected this argument that Physics practicum in laboratory is very helpful in acquiring of skills. Hadson said many students after secondary level don't acquired basic skills i.e. they can't use stop watch properly to measure a time interval, they cont properly form an electric circuit by using circuit diagram. Hadson also argued that this practicum is based on some basic skills and these skills have nothing to do with understanding of concepts of science. Woolnough also supported Hadson views. According to Woolnough (1991) some practical involve difficult task i.e. assembly of apparatus. In such practicum students focus more on setting of apparatus and less on observation. Woolnough suggested such apparatus should be presented in demonstration form. So that students can get a chance to spend more time for interactions with ideas. In another study Abrahams (2009) found that students like practical method then theory. But the reason for this likeness is that students feel laboratory is less boring than

normal classes. Their likeness does not reflect effectiveness of practical work.

The aim of science is to promote an understanding of scientific concepts in the students so that they may be able to explain phenomenon around them and capable to control some of them (Millar, 2004). Researches show that practicum is not proved as an effective tool for development of understanding in students. Students did not find any connection between what they learn in class and their daily life. The knowledge they got in inert for them. For example, Hodson (1990) report that practicum is not an effective tool for understanding. Students can understand well by other method of teaching as compared to practicum. Dillion, Prieto and Watson (1995) also support this school of thought. According to them one reason of this poor effectiveness may be is how practicum is implemented in schools. According to Tugel's (1994) findings practicum at school level does not offer any challenge to students it is like a cookbook style. Students just follow a procedure. Most students do not follow what teacher is attended to them (Woolnough, 1991). Practicum is considered a source for development of scientific attitude in students. These attitudes are open mildness, willingness to consider evidence, objectivity. According to Hodson practical work does not promote such attitudes in students. Hodson further said that the target of such practical work is a correct answer and students mainly focus on that correct answer. Consistency with answer is the text book is basic requirement of such practicum work. Therefore, practicum is used as a tool to verify answer. There is no investigation involved in it. Science is an accumulated body of knowledge and a process of knowledge generation (Schulz, 2009). Practicum enables a student to learn scientific skills helpful in generation of knowledge. Physics practicum develops in students a habit of thinking and makes them capable to solve problems of daily life using their scientific knowledge.

2.5 Effectiveness of Physics Practicum

The measure of effectiveness of a Physics Practicum is very important. We have a wonderful model developed by Millar, Tiberghien, & Le Marechal model (2002) as a part of European lab work in science education project This model is shown in figure 4 (Ian Abrahams & Robin Millar,2008). This model is also known as model of effectiveness. This model highlights different stages involved in developing a teaching learning activity. This model is a wonderful tool to measure the effectiveness of a teaching /learning activity**.**

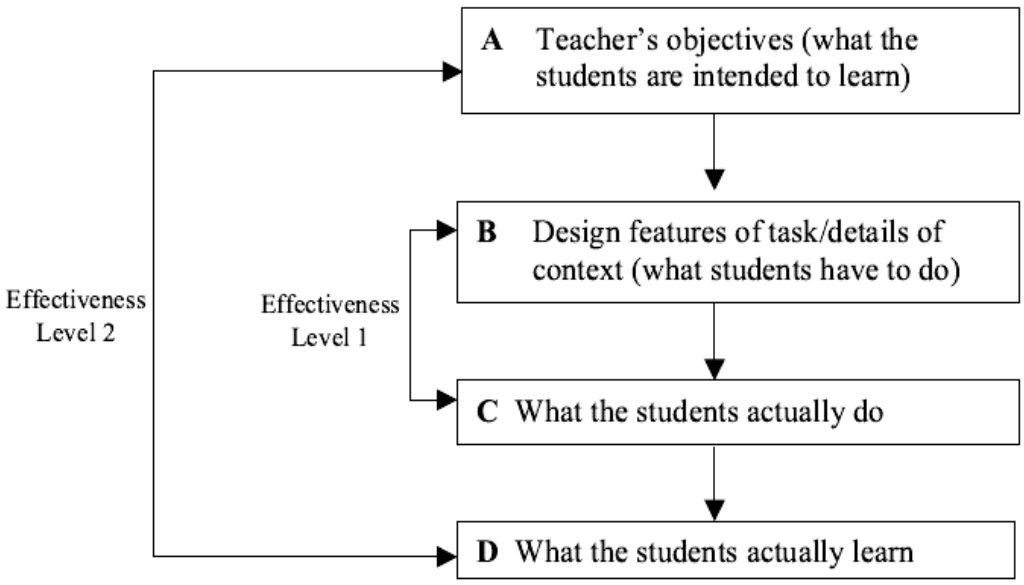

Figure 2.3: Model of the process of design and evaluation of a practical task, 2002

According to this model the effectiveness of a teaching learning activity can be measured by considering different steps of its development. Millar, Tiberghien, & Le Marechal (2002) say that first stage in developing a teaching learning activity is the learning objectives. Learning objectives are the benchmarks in the mind of developer. These benchmarks should be achieved after the completion of teaching/learning activity. According to Millar, Tiberghien, & Le Marechal model

(2002) learning objectives are the base of teaching learning activity. There are several factors that affect the learning objectives. These are

- The developer's views about science
- The developer's ideas about nature of science and of the enquiry process.
- The developer's views about understanding
- The context of activity

The learning objectives are in the form of statement(s).

The second stage is about transformation of these learning objectives into an activity. At this stage it is decided that what kind of task a student should perform in order to achieve the desire learning objective. Details of activity are specified at this stage. The activities must be translation of learning objectives. Designed activity is greatly affected by learning objectives. (Ian Abrahams & Robin Millar,2008)

According to third stage of Millar, Tiberghien, & Le Marechal model (2002) students are observed while performing activity. The performance of students is influenced by various factors which are

- Students understanding about science
- Students competency to use the apparatus
- Students views about understanding
- Context of the activity

This third stage is very important. He the developer of activity can observe what a student is doing and what is in his/her mind. Developer may find student according to framework in his mind or marginally away from it. These observations will help him to improve the design.

The fourth stage of this model is related to what a student has actually learned. Here a comparison is made between what a student have learned what was intended to

learn by him.

According to Millar, Tiberghien, & Le Marechal model(2002) during third stage when we are observing that what a student is doing and then compare it with what he is intended to do will give the magnitude of effectiveness of the designed activity. This effectiveness has been given the name of "effectiveness 1".

Normally when people talk about effectiveness of a teaching activity, they mean gap between what a students have learned and what he is aspect to learn. This effectiveness can be measured by comparing stage 1 and stage 4.According to Millar, Tiberghien, & Le Marechal model (2002) it has been given name "effectiveness 2"

Main purpose of practical work is to develop a link between two domains. These domains are domain of observables and the domain of ideas as shown in figure 5 (Ian Abrahams & Robin Millar, 2008). In some practical activities role of ideas is minor. In such type of activities our requirement is to observe an object or some material and remember facts about it. But in some other practical activities domain of ideas have an active role. In such activities thinking is as important as doing. In such activities we need to look what student do with ideas and what they do with object. (Ian Abrahams & Robin Millar, 2008)

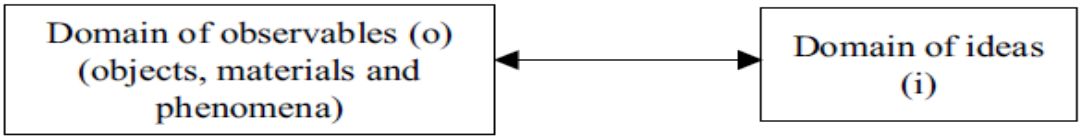

Figure2.4: Link between domain of observables and domain of ideas

2.6 Bloom's Concept of Learning and Higher Order Thinking

According to Bloom, B., 1956 presented his all-time famous Taxonomy. The idea behind this work was to ensure that learning should transform higher order

thinking. Learning is not about memorization of some facts. It is much more than that. Bloom's taxonomy highlight the various level of level of learning. Bloom's taxonomy is very help full for a teacher to plan learning activities and assessment practices. In 2001 revised version was presented by Anderson and Krathwahl. The intent behind this work was to enable teachers to bring learners from acquiring information to practical application of knowledge that they have got from learning. According to revised version of Bloom's Taxonomy there are six levels of cognitive learning. These six levels are remembering, understanding, applying, analyzing, evaluating, and creating as shown in fig 6 (www.google.com)

. This mean a good learning must enhance these six levels. A teacher must assess the impact of his teaching according to each of these levels of cognitive domain. This will not only help a teacher to measure the effectiveness of his teaching but also to help him to adopt appropriate teaching strategies. Bloom's taxonomy is a wonderful road map for a science teacher to evaluate his teaching. Higher order thing must be groomed in science teaching.

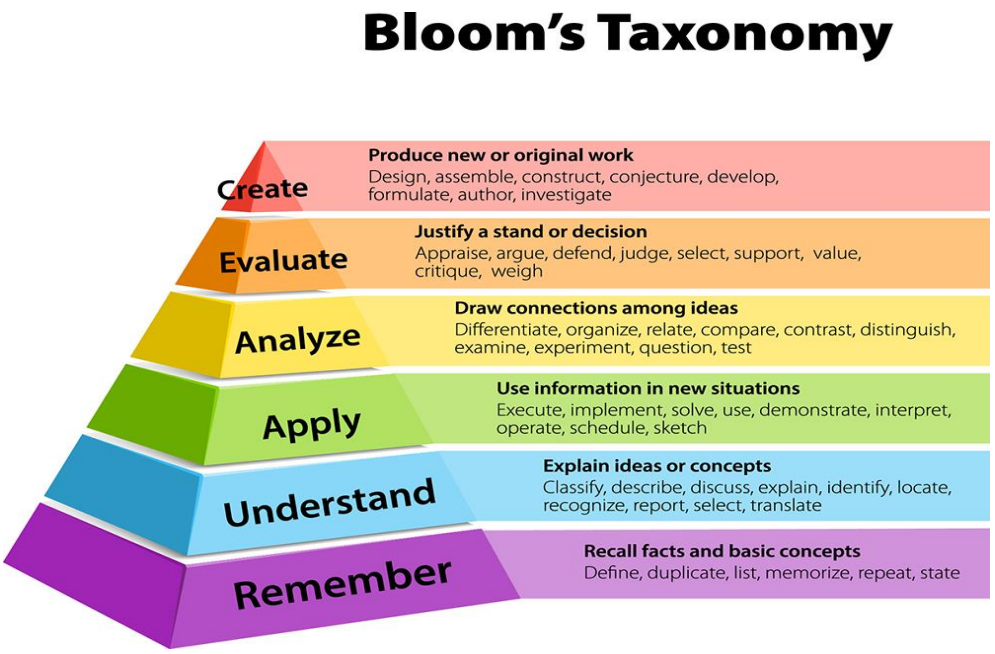

Figure 2.5: Bloom's taxonomy (Forehand, 2011)

2.6.1 Remembering. According to Bloom's taxonomy this is the first level of Remembering. Remembering is basically recalled of the knowledge and concepts that a student has gain after teaching.

According to Johnson-Laird (1998) remembering consist of five steps

i. Registration of information and data
ii. The mental representation of the information
iii. The sustaining of the memory
iv. Recollection of information and data
v. and the retention of the memory during thought processes

Remembering is considered as the base of cognitive domain. According to Bloom's remembering is the base of knowledge. There five ways to enhance remembering

(i) ***Focus on information*****.** To enhance remembering attention must be given when lecture is being delivered. This will also help in proper encoding of information. If at the end of academic year students of secondary level are asked about name of third chapter of their physics book, most of them will not be able to apply. Reason for this is lack of their attention. To enhance remembering students should made attentive. If during lecture a student is engaged with other students or with his geometry box this will affect his remembering about topic being delivered. The Information reflects back and is not absorbed by the mind. Multitasking tasking is a great barrier for remembering. Retrieval of information is not a major concern. Major problem is that a student has never got information.

(ii) ***Generate cues*****.** A person can recall 36 percent more facts by self-generated cues (Mantyla, 1986). These cues are supportive for learning because the tied the target information with personal experiences. Self-generated cues helpful in remembering develop a link with long term memory and also make difficult

information understandable. Many students who face difficulty in memorizing the trigonometric ratios can easily memorize them by clue “Some people have curly brown hair through proper brushing” as shown in fig 7(www.google.com)

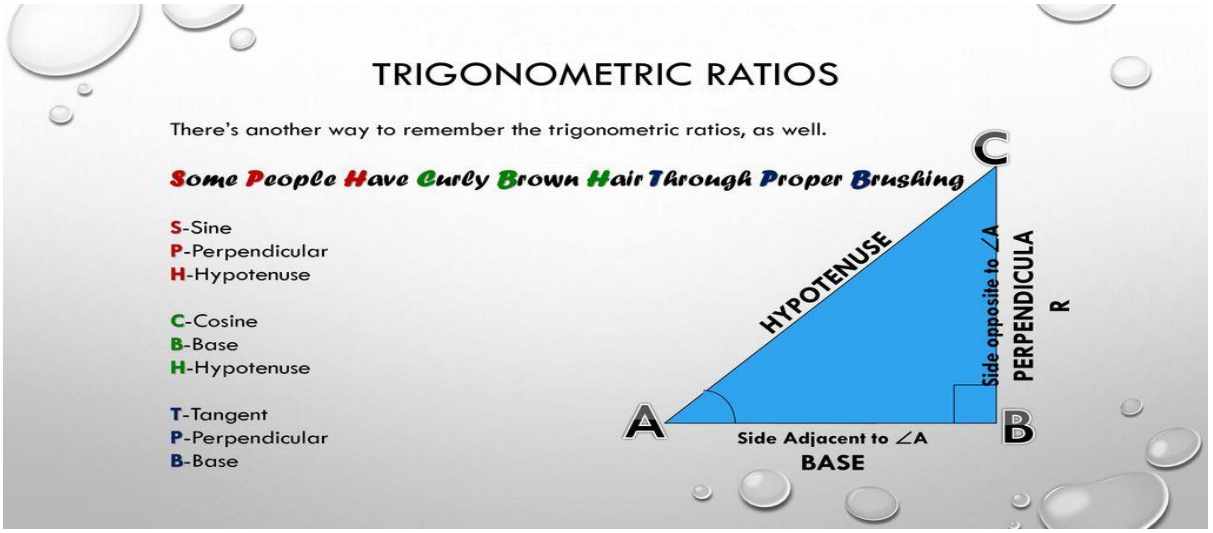

*Figure 2.6: Trigonometric ratios (*Vience, 2017)

(iii) ***Create context.*** Context means explanation given before the start of lecture. It has deep connection with remembering. It helps students to enhance their learning. Context not only helps in focusing mind but also create interest in learner. This context will also play a role in recalling of knowledge. A teacher may use a picture or told a story to his student as a context**.** The more interesting the context the more effective it will be for remembering. Role of context in remembering can be understood by following example. If a person has lost his mobile at some unknown location. He will recall all the places he has visited that day and will visit them to find his location. In this case context is being used for remembering.

(iv) ***Testing repeatedly*****.** Many psychologists believe that testing is good for remembering. According to Roediger and Karpicke (2006) reading a paragraph and then try to recall it make it more helpful in remembering as compared to reading it

again and again. A teacher may use different type of test to enhance remembering of students. Student may use self-testing technique to enhance their remembering. Reading a material again and again without testing gives a false sense of confidence. When such students try to remember they fail.

(v) *Deep processing*. Deep processing is also very helpful in remembering. By deep processing a learner can make information meaning full for him. Deep processing means thinking about information and to create a link between them and own personal experiences. For example, you might try to fit a lesson from electromagnetism to the knowledge you already have about magnet. Different strategies of remembering are

- Paying attention to key distinctions
- Explore it further
- Link the information with your life
- Further elaborate information.

According to Craik and Lockhart (1972) Deeper the information is process, longer they will last in memory. There are two main categories processing

- Shallow processing: In shallow focus is on physical qualities like structure, style of letters or on sound
- Deep processing: It is about link with other words.

2.6.2 Understanding. Understanding comes second in hierarchy of bloom's taxonomy of cognitive domain. Understanding is ability to think and act flexibly about what we know. If a student can trace similar situation in another case that he has learned then this mean he has understanding. For understanding a teacher must aid students to make connection prior knowledge. According to bloom's taxonomy there must be element of remembering for understanding. Understanding is very important

learning skill. Understanding does not mean lots of knowledge. For example, many biologists had more knowledge about species then Darwin. But they have not revolutionary understanding about these species which Darwin had. Darwin knew less but has more understanding. Understanding does not require more knowledge it demand in depth of knowledge. Understanding requires practice and takes time. Understanding of lesson is similar to getting below the surface for gems. The evidence of misunderstanding of students is very valuable for teachers. If students especially attentative one is showing misunderstanding in any topic this it is not a matter of a simple mistake. It highlights that there is no transfer of knowledge. The teachers instead of being frustrated must reconsider his teaching strategy.

Understanding depends upon following factors

i. Intellectual ability
ii. Motivation of students
iii. Prior knowledge of students
iv. Attention span

According to Grant Wiggins & Mc Tighe (Understanding by Design) a student will have understanding about a concept if he can explain, interpret, apply, have perspective, empathize and have self-knowledge. Understanding of students can be checked by

i. Formative assessments
ii. Asking students to summarize lesson
iii. Using quizzes
iv. Getting student's reflection

There are two types of understanding.

(i) Apparent understanding

(ii) Real understanding.

2.6.3 Applying. Applying is third stage of Bloom's Taxonomy. According to which a student must be able to apply the knowledge that he has learned in a new situation. For example using Newton's law of gravitation to find solution of a problem. Remembering and understanding are bases of applying. For effective teaching a teacher should make sure that his students are capable of applying the knowledge that they have gained. A teacher can produce this skill in his students by taking following measures.

i. Maximizing initial learning experience
ii. Activate student's prior knowledge
iii. Frequent practice
iv. Group learning
v. Assess his knowledge organization. This will help to find gaps

If students are failed in applying the concept, they have learnt the there is something wrong in teaching learning activity. There may be one of the following barriers that is affecting application of knowledge by students

i. Teacher's lack of knowledge
ii. Poor quality of learning material
iii. Poor time management
iv. Poor learning assessment
v. Overambitious curriculum
vi. Student's diversity
vii. Lack of home support for students learning

2.6.4 Analyze. Analyze means break down of information in parts and consideration of each part separately. It is ability to examine a large volume of data

and identification of different trends in that data. An analyst goes one step beyond from just reading and understanding of information. Analyzing comes fourth in bloom's hierarchy. It is the first level of higher order thinking. It is very important skill because it gives an insight of information. Analyzing is basically examining a concept or situation from multiple perspectives. It is the stage where a student starts understanding the existing knowledge. Analyzing makes more familiar with scientific concepts. Some important types of analysis are

i. Critical analysis
ii. Descriptive analysis
iii. Quantitative analysis
iv. Qualitative analysis
v. Prescriptive analysis

It is very important for a teacher to make efforts for development of analytical skills in his students. Analytical skills of a student can be developed

i. Reading books
ii. Playing brain games
iii. Be observant
iv. Practicing Math's problems
v. Joining debate clubs
vi. Expand world view

2.6.5 Evaluate. Though bloom placed evaluation at the top level of his taxonomy but Anderson and his colleagues consider it after creativity at fifth level. Because they believe that creativity is a mast complex skill then evaluation and evaluation is a requirement for creativity. Evaluation is defined as the ability to deal with information in deductive and inductive ways. Evaluation makes a learner to

visualize a bigger picture behind the facts. Evaluation skills can be developed in students by

i. Making them to participate in analysis-based projects
ii. Identify analytical tools that can be helpful for students
iii. Giving students feedback on their analytical work
iv. Making them to practice about their analytical skills

Evaluation is very important cognitive skill. A student can evaluate if

i. If he is able to use prior knowledge
ii. He can form and support on opinion
iii. He can distinguish essential data from information

2.6.6 Create. By using imagination and critical thinking development of new and meaningful ideas is known as Creativity. Creativity is not reproduction of what already has been learned. It is generation of new product. The new product may be a principle, an artwork, a model or an assignment in class room. According to Bloom's taxonomy of cognitive domain top level of higher order thinking is creativity. It is most difficult skill to master. For creativity all other cognitive skills are required. Creativity enhances learning because it boosts motivation, develop understanding and promote joy. Creativity is helpful in dealing with ambiguous problems, for survival in fastly changing world, to overcome the economic issues. Creativity generates new knowledge and help in verification of existing knowledge. Alone Jordon Starko (Creativity in the classroom) point out that inquiry-based learning and problem-solving techniques are very helpful in promotion of creativity among students.

Creativity is always have been a concern of educationist. It play very important role in science education. In Canada creativity is considered as one of the common essential

for learning. In U.S.A one of the goals of education is to promote critical thinking in the students. In Korea the National Curriculum defines educated persona as creative. According to standards set in National Curriculum of Physics (IX-X) 2006 students will be able to identify and solve problems creatively. Students can be made creative by

i. Create a conducive environment
ii. Use creative instructional strategies
iii. Allow students to make mistakes and take risk
iv. Give feedback to students about their creativity
v. Give students creativity-based assignments
vi. Appreciate students for creative ideas, thoughts and products
vii. Try to develop intrinsic motivation in students
viii. Do not limit assignments to some specific format, for example instead of writing they may make a model, design a plan and record a video.

There are many barriers for creativity. It is very important to overcome those barriers. Some of these barriers are

i. Fear of failure.
ii. Non incentive.
iii. Personal beliefs
iv. Pressure to produce immediate results
v. Bureaucratic policies
vi. Poor commitment to innovation

2.7 Facts about Physics Practicum

2.7.1 In appropriate Subject knowledge of teachers. Teachers are very crucial role in of our education system and play a vital role in enhancing quality of

education (Nizamettin Koc, Bekir Celik 2014). Efficient teaching of Physics practicum at secondary level demands a sound knowledge of Physics and clarity of concepts for a teacher. Confidence of a teacher for teaching science depends upon its own scientific knowledge and understanding (Whitby, 1993). Teaching of Physics is a very challenging job. Many teachers avoid the using of Physics Laboratory because of lack of this competency in them. For example, if a teacher is not clear about nature of light and its behavior in different medium then how he can guide his student to measure refractive index of glass? Some teachers even don't know who to perform experiment. Such teachers hesitate to take their students in laboratory. Teacher knowledge and student's academic achievements are parallel to each other. Inappropriate subject knowledge of teachers has adverse effect on student's academic performance. Maurat Tchoshonov et al, 2008). Standard of science education in Pakistan is not satisfactory. One of the reasons for this inappropriate standard is insufficient knowledge of teachers about their subject. For this reason, they discourage the questioning (Mavlavala, 2016). If we look at the educational criteria for science teacher at secondary level for government institutes we will find that it is minimum B.Sc with B.Ed. There is nothing wrong with these criteria. Also, selection through N.T.S is done to make sure that selection should authentic and on merit base. There is no doubt that teachers are selected according to these prescribed criteria. But due to shortage of science teachers in Government schools science subject are allotted to those teachers who have no sound knowledge of these subjects. In numerous cases even humanities teachers are teaching physics at secondary level. This practice is very prominent in rural areas.

According to Hussain et al (2020) another reason of lack of competency of physics teacher is that after getting government jab the teachers feels them secure.

They stop efforts for further upgrading of their knowledge. Because they believe that they will get nothing for this. As there is no reward for extra efforts in government sector so teachers are not motivated.

2.7.2 Academically low students. Every student in a school has different IQ level which makes him a unique student. Some students are sharp in picking of concepts while others are poor. A teacher has to take care each of them as per his or her specific needs. In our country a sufficient portion of students are not good in picking. These academically weak students at secondary level are also a factor for poor standard of practicum. There are multiple reasons for weakness of students in studies. Students being slow learner, parents income, parents education, family structure, teachers motivation, teachers allowing students to consult, teaching method, teacher's education, peer influence and class room management are main causes of poor academic performance (Onderi, Kiplangat & Awino 2014)

According to Hijazi and Naqvi (2006) attendance in studies, allocated time for studies, mother age and education contributes in dissatisfying academic performance of students.

According to Olayiwola et al (2011) parental background, good attitude towards studies, and sufficient educational resources have very positive effect in academic performance of students. These weak students increase the load of teacher. One main reason of these weak students is that our examination system is based on memorization. Students pass their examination up to middle by "Rote learning". They don't bother to understand thing. These students are conceptually not very sound. When they reach at secondary level things become difficult for them. It is not easy for a teacher to handle with such students**.** Learning style and academic system affects the academic achievements of a student (Cassidy and Eachus, 2000). Second reason of

poor base of student is that their parents are not educated and they don't get any help for their studies. In overcrowded schools where teachers have to teach a big number of students in class and there is no possibility of individual intention, how these students perform well.

Another reason of weak base of students is poor teaching standard at primary level. In government schools science teachers teach without the aid of multimedia, WI-Fi and smart board. There is no frequent use of laboratories at middle level. In majority of primary and middle schools there are no science laboratories. Black board is the only tool for a teacher. The students are blank in scientific concepts. Teachers just read from the book and students just listen to him. Students have no freedom for asking the questions. Examinations are only for testing the memorization of students. Higher order thinking never tested. Students at primary and middle level use unfair means to pass the examinations. A theoretical model of weak Students' academic performance presented by Shanthi bavani (2015) highlights various factors that affect performance of students. This model is shown in figure 8 (Shanthi bavani, 2015)

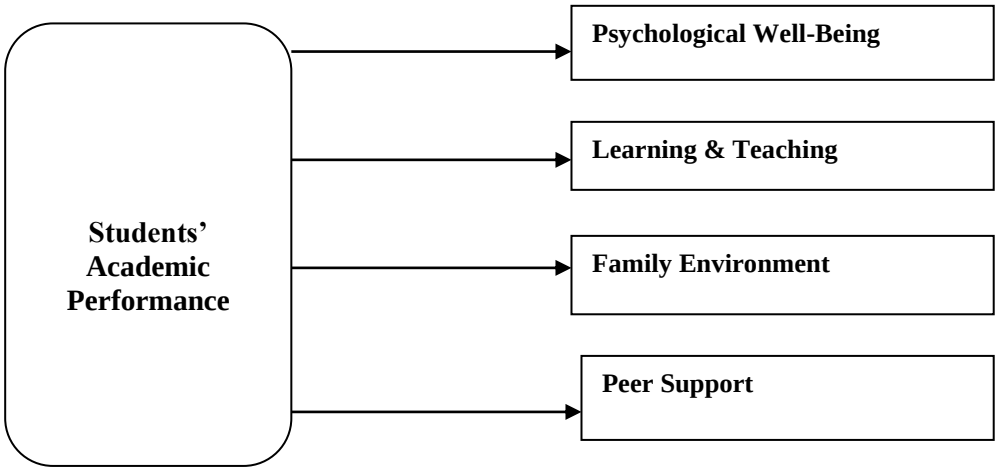

Figure 2.7: Theoretical Model of Weak Students' Academic Performance
(Shanthi bavani, 2015)

2.7.3 Great number of students. According to findings of studies conducted by Nizamettin Kac, Bekir Celik (2014) there is a strong relation between student teacher ratio and achievement of students. Greater number of students in class makes teaching difficult. It is a common believe that size of class affects the teaching learning activity. Smaller the size of class better will be the e of class better (Blotchford & lai 2012) Researchers of USA, China, Japan and many European believe on effectiveness of small size of class. Efforts are being made in these countries to reduce size of class. In Finland, Iceland and UK number of students in one class is 19 and lower. While in Turkey and Korea number of students in one class is 28 ND 37 respectively. According to the research conducted under CSPAR project in United Kingdom, Class size noticeably affects the academic success (Blatch Ford, 2003).In our government schools the class rooms are overcrowded. Most government schools have overcrowded classrooms. A teacher has to deal with 50 to 60students. (The News Tue, April 14, 2020 During laboratory work it become very difficult to teach such huge number of students. Mast of time is wasted in maintaining discipline in the laboratory. In physics laboratory a science teacher has to check the performance of each and every student and then guide him accordingly. Each student needs teacher's attention for clarification of his queries. Is it possible with 50 to 60 students?

For example, if students are measuring the critical angle of angle of glass by using glass prism. It is humanly impossible that a teacher con guide 50 to 60 students with in two periods. So what teacher do they give a general demonstration which is not sufficient?

The amount being spent on education in Pakistan is very less. As a result of which there

2.7.4 Assessment practices for practicum in Pakistan. Assessment is a process that facilitates student learning. Assessment is an integral part of teaching and learning process. According to Puckett & Block (2000) Teaching, learning and assessment all are happening at same time. Assessment is not only helps in judging students but also helps to find out how much learning activity is effective. Assessment is therefore not only of learning but for learning. Assessments also provide opportunities to teachers to review their teaching strategies. Assessment can done by asking questions about how, why, what and whom. According to research of Gidding & Fraiser (2006) the extent to which objective of Physics practicum can be achieved depends a lot on the mode of assessment. They also argued that mode of assessment influence student's attitude toward practicum.

Halali (2002) says that in Pakistan in many cases only tool for assessment is through paper and pencil test. By these assessment students learning outcomes are measured in term of what they have memorized. These paper and pencil test don't give real picture of student's understanding (Halali, 2002). Abehe Adugna Chala (2019) writes in his research work that we need better ways for assessment of practicum to ensure the mastery of certain practical skills as well as scientific reasoning may thoroughly be assessed. Shah and Afzal (2004) have also raised questions on assessment system in Pakistan. According to them selected material is tested again and again in board examinations. This leads toward selective studies and memorization.

During practicum examinations examiners normally don't assess their performance. They just ask few viva-vice questions. Young's (2011) research supports this view. Such assessment do no judge real competence of students and have very narrow scope. There are many reasons for this. One of the reasons is

unavailability of apparatus. In many examination canters apparatus is not available. Secondly many students can't perform practical. They don't know the use of apparatus and argued that have never use apparatus in their schools. So pracicum examiners assess students by viva-vice. Another reason is that to assess the performance of each and every student is a hard job. Normally examiners avoid from making too much efforts.

In our country influence is made to get marks in practicum examination. Even educational institutes are also involved in this practice. They do this to make a reputation of high standard institutes. Some private academies assure their students for maximum marks in practical examination. (Pakistan today 2011)

Assessment is related about four questions. These questions are why, what, whom and how as shown in figure 9 (Heffernan & Reid, 2007).The teachers should know that what they are assessing in their students, what they will assess, how they will assess and for whom they will assess

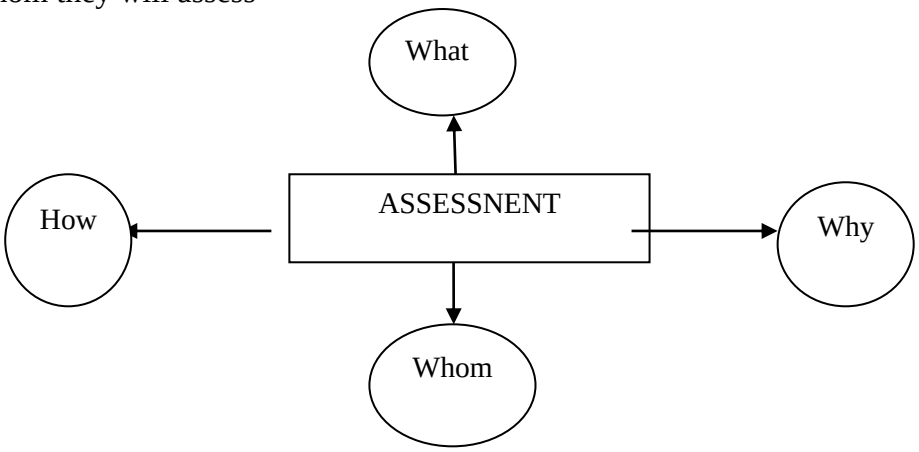

Figure 2.8: Assessment scope (Heffernan & Reid, 2007)

An authentic assessment is one which fulfill following functions summative function, formative function, evaluative function and educative function. Summative function give idea about achievements of student, Formative function give idea of effectiveness of teaching, evaluative function give idea about curriculum experience

and help in curriculum deplaning and decision making while educative function engage students in learning process during assessment.

2.7.5 Preparation practices for practicum in Pakistan. Teachers use a syllabus book to teach. They have never visited laboratory with their students to perform experiment. (The Express Tribune, 15 April, 2020)

In our public schools where laboratories are well equipped, students are not allowed to use apparatus because of fear that they may damage the apparatus. In these schools only teachers uses apparatus to demonstrate practicum. (Nargis Mavlavala, 2016)

In Pakistan mostly practicum is not performed in laboratories. There are many reasons for this. In some school's laboratories are not equipped while in some other schools teachers are not available. There are some such schools where both apparatus and teachers are not available. The unluckiest thing is that even those schools where teachers and apparatus is available practical are not performed. Banners are displayed across major cities clamming "Practicum preparation within 14 days at just Rs.5000 (Pakistan today 2011)

2.7.6 Medium of instruction. If you speak to a person in a language that he understands you speak to his head and if you speak to a person in his mother language you speak to his heart (Nelson Mandela, 2007). Language that is use to teach in any discipline at any level of learning is called medium of instructions. Medium of instruction plays very important role in teaching and learning because it is main source of transmission of knowledge. The medium of instruction is a controversial issue in Pakistan (Saira Ijaz Ahmed 2011). This issue also affects Physics practicum at secondary level. Even after the seventy year of independence we are undecided about medium of instruction in our country. Our policymakers are confused on this issue. There are five major languages that are spooked in our country Punjabi, Sindhi,

Pashto, bolo chi and our national language Urdu. But in our country English is considered best for education. In recent past Punjab government decided that medium of instruction from class I to onward will be English. But soon it was transpired that this could not be implemented.

According to Saira Ijaz Ahmed (2011) medium of instruction should have following characteristics

- Medium of instruction must ensure understanding of students
- Teachers and students should have full command over that language and confidence to speak that language
- Medium of instruction should be helpful in raising cognitive abilities
- Medium of instruction should not create any superiority or inferiority complex among learners
- Medium of instruction should act as a barrier in conceptual understanding of students.

According to above characteristics English cannot be preferred as medium of instructions. Use of nonnative language as medium of instruction has very adverse effects on teaching and learning. Because teachers and students faceses difficulty in exchange of ideas due to poor vocabulary. As a result, student could not understand thing and rely on rote memorization. In Pakistan many students fail to understand the lesson because of inadequate language skills. Best language for medium of instruction is mother tongue (UNESCO).In this respect Urdu is the best language for science education in our country. But terminologies are a problem here. Students reading science book in Urdu are facing a more painful situation. Because science book written in Urdu retain English terminologies that are transcribed in Urdu.

2.7.7 Allocation of budget for science education. In Pakistan conditions of secondary school laboratories is not very good. According to a report of Global Education Monitoring (GEM) Pakistan spends 2.6 percent of its GDP on education. While Bhutan spend 7.4 percent, Maldives 5.2 percent, India 3.8 percent, Nepal 3.7, Afghanistan 3.3 of their GDP on education. Whereas Bangladesh spends 1.9 and Sri-lanka spend 2.2 percent of their GDP on education. This comparison makes clear where we are standing.

The amount being spent on education in Pakistan is very less. As a result of which there is shortage of schools and teachers which put more burden on existed schools. Pakistan spent US$ 2000 on its one soldier and US$ 2 on one student (Riaszddin, 2002). Laboratories require funding on regular basis. In Pakistan there is shortage of funding for secondary school laboratories which is a matter of great concern. Research carried out by Muhammad Naeem Awan (2015) also supports this fact. Due to shortage of apparatus one set of apparatus quality practicum cannot be ensured.

Even available budget which is very less is often not used for laboratories. This budget is used for other purposes. The reason behind this is attitude of school administration.

2.7.8 Allocated marks for practicum in Pakistan. Scheme of studies for secondary classes is given in the table 2 & table 3 (Ministry of education, Government of Pakistan). If we look at this scheme we will find that weightage for Physics practicum for each science subject is just **15%,** which is very less. Higher order thinking demands more mind processing. Therefore, marks allocation for practicum must be increased. Since theory contains 85% of total marks so it is natural that students will pay more attention on theory. School administration and teachers

also focuses more on theory then practicum because of greater marks for theory portion. Because good percentage in theory paper will produce result and good result will earn prestige for their institute. Students believe that focusing on practicum is wastage of time. They know that even without making efforts for practicum they will get considerable marks in practicum So students show a very casual attitude towards practicum because of this less mark weightage on the other hand they put their full efforts for theory examination. Teachers and parents also support students for this attitude toward practicum. Sufficient marks weightage will not only motivate students toward practicum but also divert the attention of teachers and school administration toward practicum. Sufficient marks weightage will help in raising the standard of science education in Pakistan. Practical work of physics cannot be implemented according to the spirit of national curriculum of physics, 2006 with present marks weightage.

Table: 2.1

Scheme of studies for secondary SSC-I

S.No	**Subjects**	**Theory**	**Practical**	**Total**
1	Urdu	75	-	75
2	English	75	-	75
3	Math	75	-	75
4	Islamiat	50	-	50
5	Pakistan Studies	50	-	50
6	Physics	65	10	75
7	Chemistry	65	10	75
8	Biology	65	10	75
9	Library	-	-	-

Table: 2.2

Scheme of studies for secondary SSC-II

S.No	**Subjects**	**Theory**	**Practical**	**Total**
1	Urdu	75	-	75
2	English	75	-	75
3	Math	75	-	75
4	Islamiat	50	-	50
5	Pakistan Studies	50	-	50
6	Physics	65	10	75
7	Chemistry	65	10	75
8	Biology	65	10	75
9	Library	-	-	-

2.7.9 Attitude of school administration. School administration has a pivotal role in achievement of quality education because all decisions are made or approved by school administration. Ornstein and Hankins (1998) argued in their research that school administration is key guarantor of successful implementation of school curriculum. They are knowledgeable and committed to the curriculum. Findings of some researches indicate that school's administrations are not very supportive in implementation of practcum. (Endalamaw el at, 2017). There are many reasons behind this attitude of school administration about practical work. One reason is many resources are required for practicum which cost lot of money. So, school management neglect practical work to save money. Second reason is students can get easily passing marks in practicum therefore school administration considers it unnecessary to put efforts for practical work. Another reason is practical work constitutes of only 15% of

total marks in marks while theory constitutes of 85% marks. For this school administration focus more on theory paper because good marks in theory paper will have a positive effect on overall school result.

2.7.10 Teacher's professional dishonesty Teacher's professional dishonesty is also a factor that affects Physics practicum. It is common observation that mostly practical examiners do not perform their duty well. They do not conduct practicum examination thoroughly and award marks according to their mood or on the basis of "safaris" (Siddique, 2011).Their attitude affects very badly the standard of practicum and disheartens among intelligent students. At practicum examination centers practicum examiners are often served with delicious foods. They are also provided pick and drop facility. This all is done to hack them and to get good marks in practicum examination. Even in some cases institutes get contribution from students for hosting the practicum examiners. Because of this dishonest attitude educational institutes and students do not take practical work seriously.

There are some practicum examination centers that are famous for their hosting. Teachers use sources to get appointment of practical examiner at these centers. In response they give marks to their students according to their will.

2.8 Practical Measures for Practicum

According to Alex Johnstone (2001) practicum work in laboratory is a very challenging job for students. It is a multi-dimensional activity and demands many things from a student as shown in figure 10 (Norman Reid & Iqbal Shah, 2006). At the start of (Heffernan & Reid, 2007) work, a student has to organize in his mind all the knowledge he has about (Heffernan & Reid, 2007) work. Either he has got it from lecture in the class, book or from library. He needs to recall the method of using apparatus. He must be skill full in using the apparatus. Must concentrate to verbal

instructions, be attentive. He must process all the experimental data.

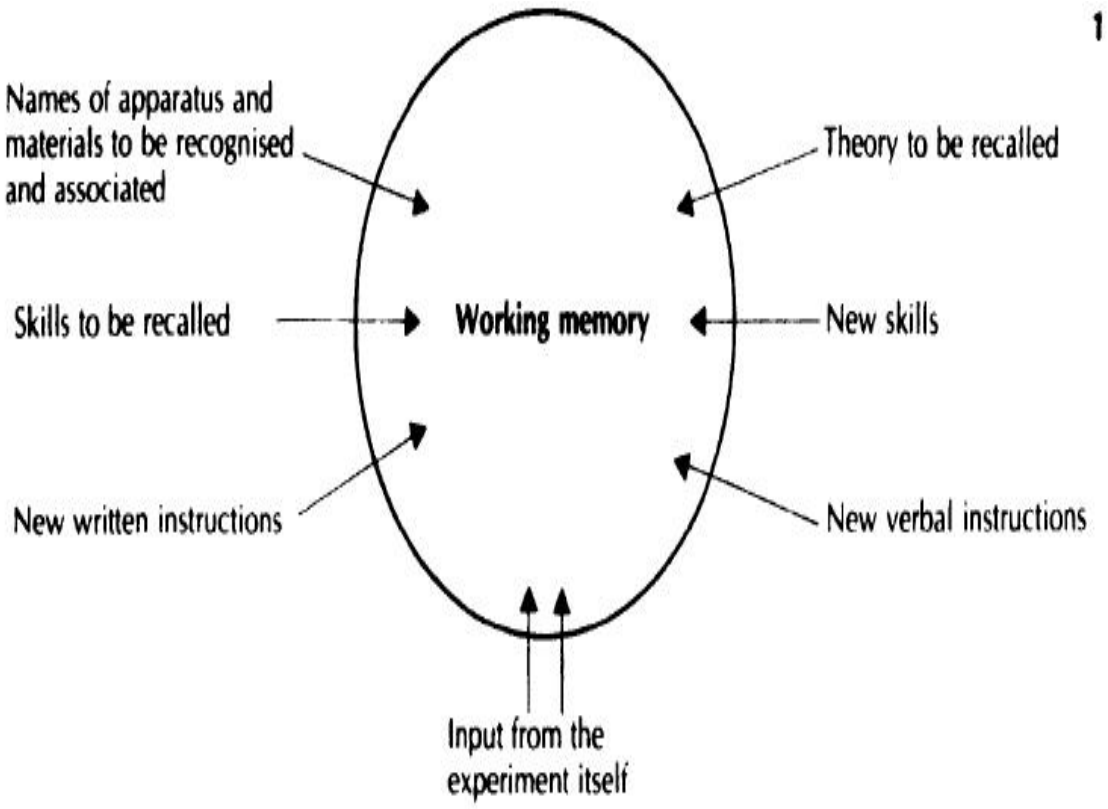

Figure 2.9: Sources of information for students in Laboratories

(Heffernan & Reid, 2007)

Alex Johnstone (2007) argues that practical work in laboratory demands hard work and consistency. Due to which many students try to use short cuts. In such short cuts they don't engage their minds. They follow laboratory procedure like a recipe. They don't engage their mind in practical work. Sometimes they just copy the work of others. According to Alex Johnstone (2001) in theory class a teacher starts his lecture from a single point. Elaborate things with a help of examples and then present a broad picture. But in practical work situation is totally opposite. A broad picture is presented to student and they have to conclude a result as shown in figure 11 (Norman Reid & Iqbal Shah, 2006)

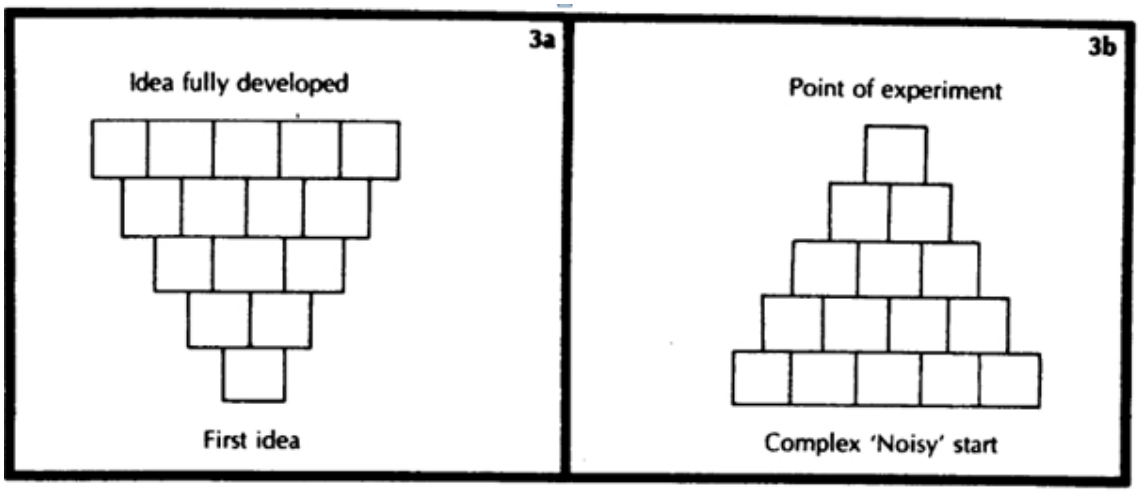

Figure 2.10: Teaching in practicum class

According to Alex Johnstone as laboratory work is overloaded so a special teaching strategy should be adopted in the class. Alex Johnstone suggested that

- Experiment should be clear
- A manual of instruction should be prepared
- Eradicate all irrelevant aspects related to experiment.
- Ensure necessary skills should be acquired by students.

2.9 Role of Practicum in Science Education

Science course of secondary level consist of

(i) Theory

(ii) Practicum

Theory means learning of science by reading, listening, discussing and writing. While practicum means learning science by doing or by using apparatus. Both have their own important. Theory provides knowledge and understanding of subject and is there for very important in development of lower order thinking. Since practicum are help full in understanding and development of certain skills so they importance in development of higher order thinking.

According to Osborne (2000) normally teachers prefer learning science by theory. There are many reasons behind this. One main reason practical method is very expensive. Science laboratory is required. Apparatus and laboratory staff are also a demand of practical method. Which is not available everywhere? Secondly learning by practicum is a hard job. Lot of efforts is required. Mostly teachers avoid from it. Another reason is that there is very strong correlation between theoretical assessment and practicum assessment. So, teachers replaced practical teaching by theoretical teaching. Wattage of marks is also a reason for preference of theoretical teaching. Theoretical portion has more marks so it is more preferred.

This attitude of teachers toward practicum is not a healthy exercise**.** It is a great barrier for development of higher order thinking in students. Many researchers stress on importance of practical work. Leach and Paulsen (1999) learning science by theoretical method only is not sufficient to achieve goal of science education. Practicum must also be given importance. Practicum is heart of mastery in science discipline. Without practicum science knowledge is inert (Muleta & Seid, 2016). According to Yager (1981) practicum should be considered as meal rather than considering dessert after the meal. A good approach towards teaching of physics is that bath ways theory and practical must be considered and no one should be neglected.

According to national curriculum of physics 2006 the aim of physics curriculum is to develop thinking process, ability to solve problems, investigating and communication skills. It is emphasized in the curricula that traditional ways of teaching will be replaced by modern teaching techniques. For nourishment of psycho motive skills opportunities will be provided to students for conducting experiments. According to research work of Hofstein & Lunetta, (2003) practicum is very helpful to teach students how to design and conduct an investigation in order to solve a problem. According to research work of Hofstein & Lunetta (2003) aim of teaching of

physics cannot be achieved without practicum of physics. According to research conducted by Talisayon (2008) practical work is help full in development of certain skills like observation, problem solving techniques, data analysis, handling equipments. These skills are use full in science learning. The main purpose of science education is to provide students conceptual knowledge in order to help them understand the nature of science. Schulz (2009) argued that practical work is helpful in learning of application of scientific method as a result of which students are able to generate new knowledge.

2.10 The Design of Learning Environments

Learning environment refers to the physical location and cultures in which students learn. Learning environment includes classroom, teachers, parents, colony, city, television, Social media etc. Learning environment is very important for students and teachers. Students learn better in positive learning environment while negative learning environment have adverse effect on learning of students (Dorman, Aldridge & Fraser 2006). Learning theories does not provide a recipe for designing effective learning environment. Developing a learning environment is not an easy job. Learning environment includes

- The goals of teaching and learning
- Activities that will support learning
- Assessment strategies
- Culture that will support learning
- Norms that will support learning

Goals for school education have been changed considerably during the last century. Now a day everybody is much expecting from school then past. Present learning goals for school education demands new learning environment. Here we

explore learning environment from four different perspectives.

According to John D. Bransford et al (2000) learning environment should be learner centered, knowledge centered and assessment centered. These aspects are shown in figure 12 **(**John D. Bransford et al 2000)

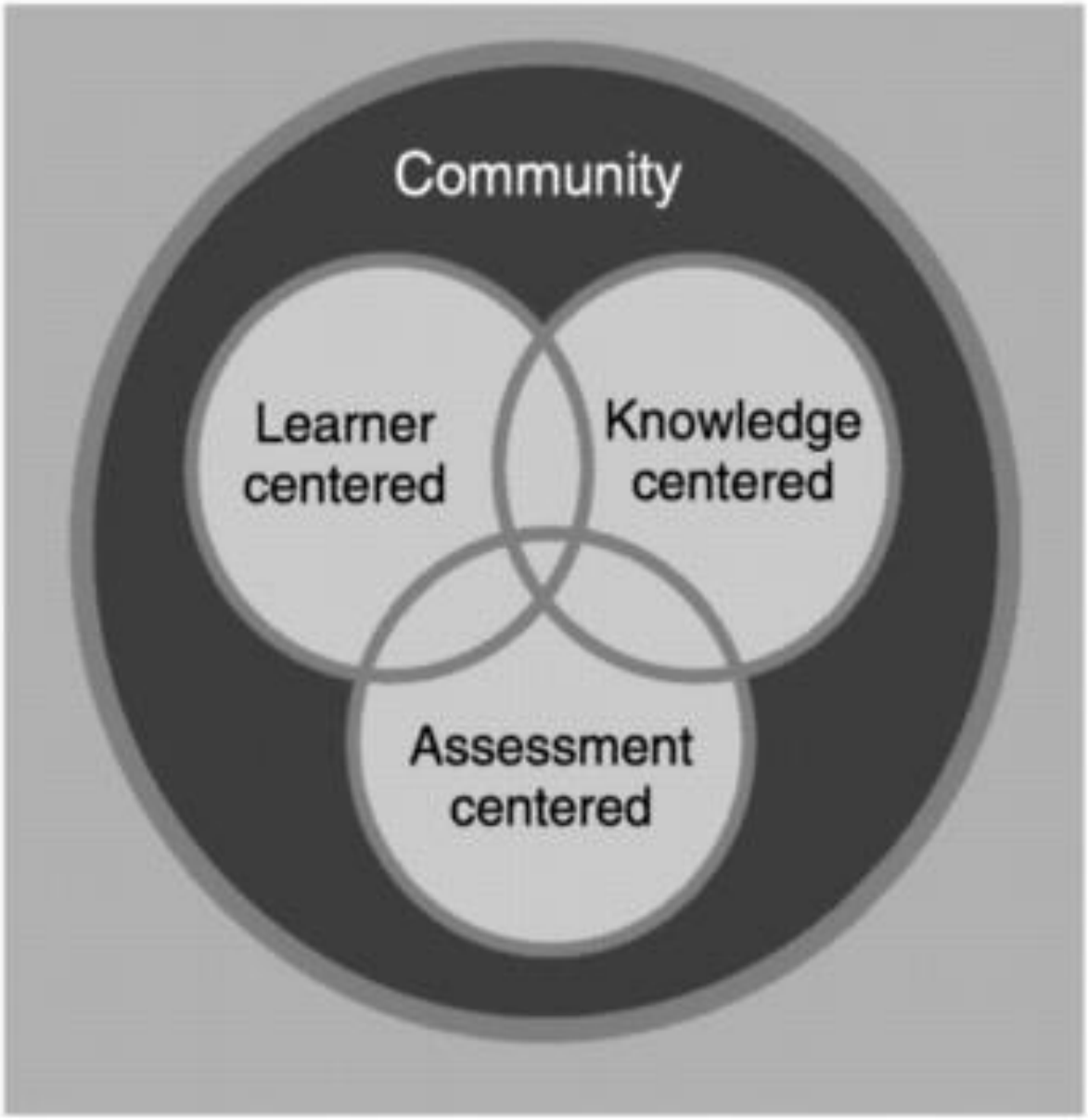

Figure 2.11: Perspective on learning environments

2.10.1 Learner-centered environment. Learner centered environment demands special focus on the knowledge, skills, attitudes and beliefs that learners

bring with him**.** Learner centered environment can also called as diagnostic teaching (Bell et al, 1980). Student's structure of knowledge must be considered. Necessary information about student is acquired through observation, questioning and conservation. Students are asked to make predictions about different situations Teacher can guide students how and why his ideas need change (Bell and Purdy, 1985)

Learner centered environment take into consideration student's cultural background and language. Because these two element play very important role in learning. Teachers in learner centered environment use the existing conceptual and cultural knowledge of student as a base for further improvement of knowledge.

2.10.2 Laboratory work must be knowledge centered. According to committee on high school laboratories U.S.A (2006) for learning laboratory work must be knowledge centered. According to Knowledge centered approach laboratory experiences must be designed in such a way that students may learn with understanding. Knowledge centered learning discourages rote memorization because it does not lead to true understanding. This approach focuses on activities that are helpful in development of students understanding.

For knowledge centered environment a teacher should planned

i. What will be taught?
ii. How will it be taught?
iii. How the activity will be organized? (Committee on high school laboratories, U.S.A, 2006)

Knowledge centered learning can be explained by following example. A teacher after teaching his students to measure length of small objects using vernier callipers may assign them to measure volume of small cylinders by vernier callipers.

Students applying their existing knowledge in new situation will find volume of cylinder by using formula

$V = \pi r^2 L$

This activity will develop their understanding about use of vernier callipers. On the other hand, by traditional science teaching student can measure length but he can't apply this knowledge in different situation. If such students are asked to measure length of different objects, they will put wrong unit with measured quantity. For example, after measuring length of a small cylinder by vernier callipers they will write answer with unit in meter.

2.10.3 Assessment for improvement in learning. Assessment must be use as a tool for learning in laboratory (Committee on high school laboratories, U.S.A,2006). Assessment provides feedback which improves learning. Teachers should take care that their feedback must be supportive not intrusive and assessment must be congruent with learning goals. For effective teaching, teacher should assess their student's abilities to link their current activities to other part of curriculum. Teachers should make efforts to build self-assessment skills of their students. Students should learn to assess their own work and their peers work. There is a common practice in our schools that after receiving grades in a assessment students move to a next topic. Feedback will be more productive if student got on opportunity to revise their thinking. This will give them an opportunity to improve them self. Moving to next topic after feedback is not much fruitful. The additional chance for assessment will improve learning of students.

There are two main categories of assessment that should be distinguish clearly

2.10.3.1 *Formative assessment***.** These assessments are a source to feed back for teachers about students learning. These assessments help teachers to know about

magnitude of learning of students (National research council, 2000).

These types of assessment are administered in the context of class room. Examples of formative assessments are test of previously taught topic, teacher's comments on notebook or on a presentation

2.10.3.2 *Summative assessment*. These assessments are to measure what students have learned at the end of course. Examples of summative assessment are teacher made test given at the end of unit are examinations taken by state at the end of semester or year (National research council, 2000).

2.10.3.3 *Formative assessment for learning.* According to researchers continuous feedback by formative assessments is very important for learning (National research council, 2000). Assessment should not focus only on knowledge but they also assess the understanding. Development of assessment that emphasize on understanding is not a complicated task. Even multiple-choice tests can be organized to assess understanding of students. Effective teachers continuously assess their students and give them feedback on regular basis. Properly designed assessments are also very helpful for teachers. On the basis of feedback obtained by these assessments a teacher can adopt an appropriate teaching method. For example, if students of class IX are not doing good in numerical of physics the teacher might think about his teaching practices to improve their mathematical understanding.

Formative assessment and feedback on the basis of these assessments is a time-consuming job. But now a day advancement in technology had made this job easy. By using MS office formative assessment can be made very easily. By advancement made in education a teacher can easily developed assessment for measurement of understanding even without using advanced technology.

Portfolio assessment is also a method of formative assessment. Portfolio keeps

the record of students work. Student's progress is discussed after regular interval of time. Students are informed about their areas of improvement. Parents are also involved in this discussion so that they can know about progress of their child. Discussions between students, teachers and parents are very important part of portfolio assessment. Without these discussion portfolio assessments are like a store that keeps the record of assessments.

2.10.4 Community centered environment in laboratory. According to latest research about teaching of science education, its leaning can be enhanced by providing a healthy environment of discussion especially with teachers and fellow beings. (Committee on high school laboratories, U.S.A, 2006)

Community centered environment boost the learning (Coob et al, 2005).Such an environment is also helpful in refining of ideas. Community centered environment gives multiple opportunities to a student to articulate his ideas the word "community" refers to several aspects of community including class room, school, home, business, nation and even the world. During discussion with teachers, parents and class fellows a student can get feedback about his ideas. Positive feedback increases the confidence of a person. On the other hand, traditional teaching gives teacher a active role. He is sole authority and orbiter of scientific knowledge. Students have no opportunities to share their thought. Traditional class room does not give any opportunity to discuss about student's misconceptions. Students get feedback occasionally.

Class rooms are very important component of community centered environment. In a class room a student interacts with and fellow students and teachers. Social norms are very helpful for learning in class room. For example, a social norm of freedom to make mistake for learning helps student in learning. Different classrooms and schools have different norms. A family also plays very

important role in community centered learning. Children are learning from their family even when family is not consciously making efforts for their learning (Moll, 1990). Success of family in learning especially in early year of child is out of question. The development in child learning from birth to 5 year is highly supported by family interaction. At this stage a child learns by observing its family members. Parents help at the early stages of child matters a lot for him. This early help of parents also matters for his secondary and higher secondary level of education of a child. If parents are educated they can make early stages of education of a child easier. It is common observation that children having initial help form parents perform better in schools as compared to those children which have not such assistance. Many recommended changes for schools are based on this strong impact of family environment. Students also join some other institutions outside their schools like sports clubs, scout association, adventure clubs etc. These institutes also have positive influence on in school learning. Opportunities of sharing one's work with other always have a motivational effect. Television is also involved in community centered learning. Before entering in school, a child spends much time in watching television. Parents want that their children should learn from television but at the same time they are also concerned about what their children are learning from television. (Greenfield, 1998). There are different verities of television programs. Some are purely educational while some are purely entertaining. While there is a category this is mixture of education and entertainment. Students can watch television alone or with their families. Television is a wonderful source for learning for children; approach to this source of learning is very easy. It also provides variety of opportunities.

A comparison of time spent by a student in school, home and community and sleep is shown in figure 13(John D.Bransford et al 2000)

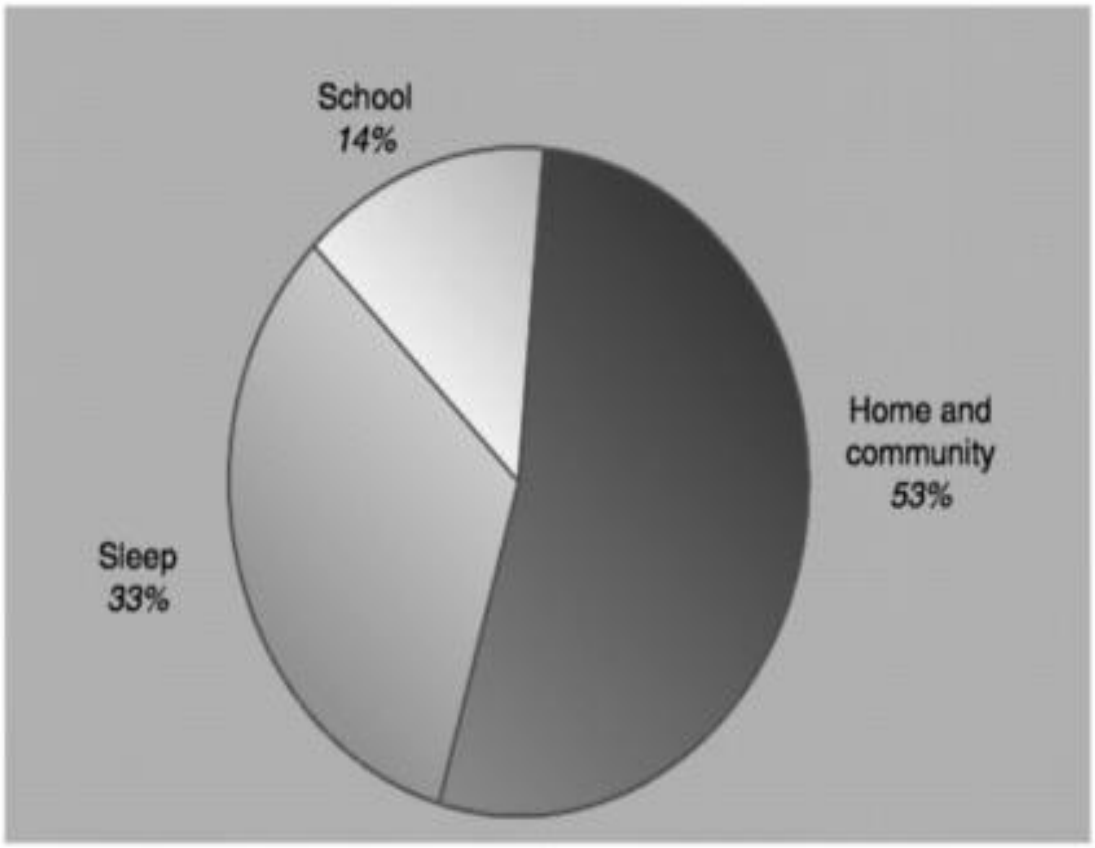

Figure 2.12: Comparison of time spent in school, home and community, and sleep.

2.11 Curriculum Development Process in Pakistan

According to Wilson (2001) curriculum is a broader term which encompasses all aspect of teaching and learning i.e. Faculty, budget, teaching strategies, evaluation and consequent students

Majeed (2009) stated that curriculum is a multi-dimensional phenomenon and includes all holistic opportunities provided to students for learning. Corriculum is the soul of a nation.

Chen (2007) defined curriculum as communication channel establish among teachers, learners, learning material and environment. It reflects cultural beliefs and political values.

The general goals of curriculum in Pakistan are

i. To develop a balance personality of child so that he may become a good Muslim as well as successful member of society.

ii. To ensure intellectual development of child with literacy of basic numerical skills and knowledge of basic Islamic values.

iii. To ensure understanding of environment and its safety.

According to ACT X 1976 of our parliament curriculum designing is responsibility of ministry of education. There is a cell in ministry of education known as national curriculum wing which handle the task of curriculum designing. The national curriculum wing works according to the recommendations of the national educational policy. Main responsibilities of curriculum wing launching of schemes of studies, text book transcript, implementation of manuscripts and strategies for continuation of various classes of educational institutions. (Jumani, 1999)

Siddque and Sultan (2008) stated that in Pakistan curriculum designing starts with the initiative of National curriculum wing. On the demand of national curriculum wing provincial curriculum committee design drafts for curriculum from class I to XII. These drafts are sent to national curriculum wing. Notional Curriculum wing first put it with nominated subject specialist and senior school teachers for their expert opinion. Then this draft along with opinion of experts is put to curriculum analysis committee. This committee consists of curriculum experts. They thoroughly analyze these drafts under the light of opinions given by experts. After through discussion the final drafts are sent for approval to ministry of education. This step wise development of curriculum in Pakistan is shown in figure 14 (Siddque and Sultan, 2008.

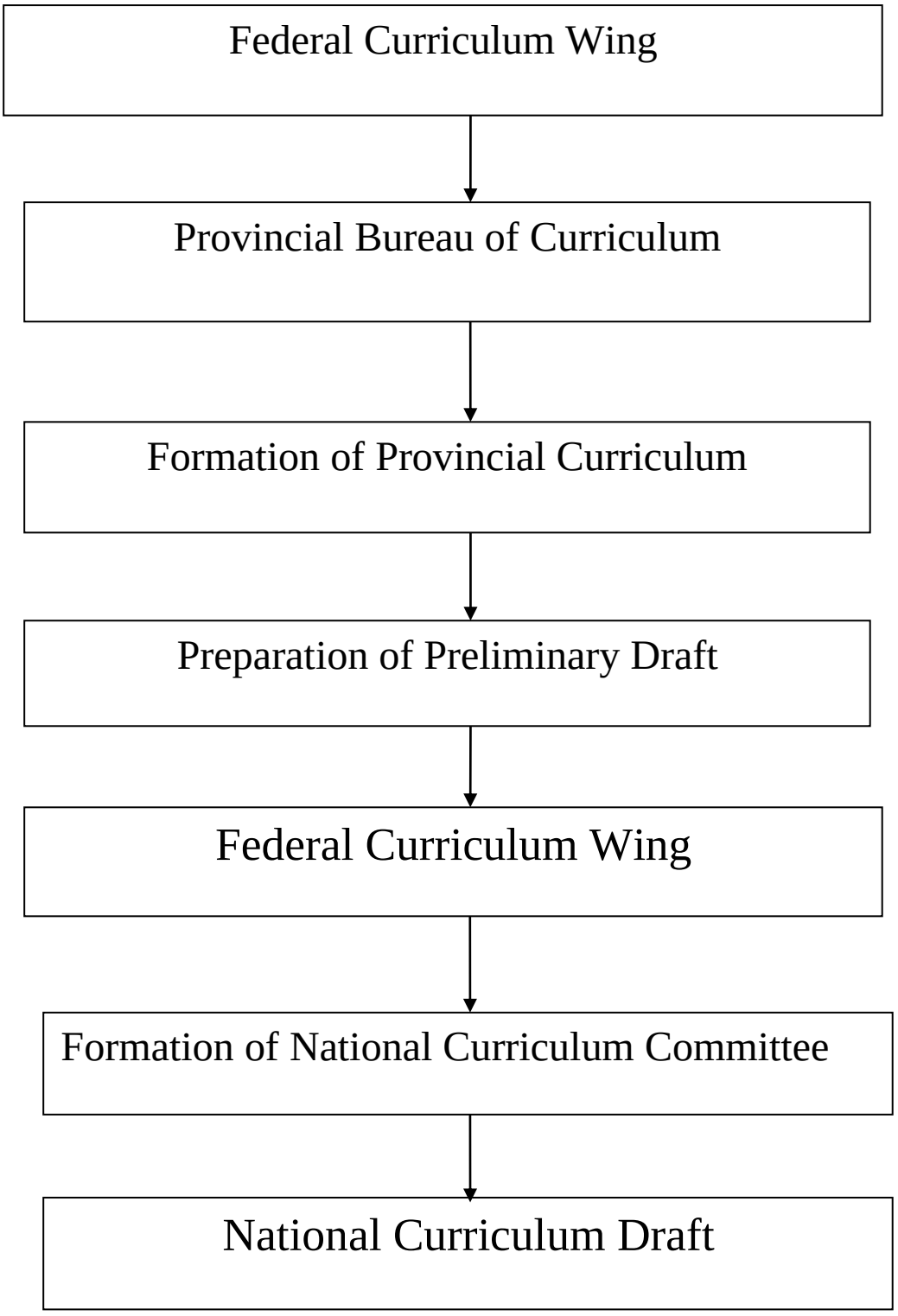

Figure: 2.13 Curriculum developments in Pakistan

2.12 Analysis of National Curriculum of Physics 2006

Curriculum plays very important role in development of scientific knowledge among students. Without effective curriculum students cannot get quality education. Effective curriculum needs changes with the passage of time. These changes modify curriculum according to needs and demand of society. These changes are very helpful in improving the quality of subject. In Pakistan changes have been made in physics curriculum since after its independence. Unfortunately, there efforts are not helpful to develop a curriculum of physics according to demands and need of time.

Present era belongs to science and technology and science has become the backbone of development (Avotri. 2008). Now battles for supremacy among nations are not fought in fields but in science laboratories. Physics is very important branch of science it plays a pivotal role in development of the world (Khan 2007). Physics is also playing very important role in nourishment of other branches of science like Biology, Chemistry, Computer sciences, Astronomy etc. Pakistan is logging behind other developed countries in the field of science especially in physics. Pakistan has poor academic standard (M. F Joubish & M.A Khurram, 2010).Pakistan needs a curriculum of physics that would meet the challenges of present time (Tariq & Muhammad Iqbal, 2018).

According to Tariq.M & M.Iqbal (2018) the objective, standard, benchmarks and learning outcomes are according to needs and demands of students but designing of book is not satisfactory. This book is not fulfilling the demands of students. This book does not cater for student's interest. Content is failed to develop logical reasoning among students Textbooks are full of factual information and lack personal relevance. Scientific language and abstract concepts makes learning very difficult and boring. Students do not find any connection between subject matter and their social

and personal life. Curriculum of physics for secondary level consists of one book which is divided into two parts. This book requires audio video aids for its teaching which are not provided to teachers. They also state that present curriculum give understanding to students but fail to achieve the goal of producing model citizen.

Education experts are satisfied with the objectives given in physics curriculum of secondary level but at the same time they believe that following objectives are not being achieved

- Develop motivation in students about learning of physics and sense of achievement
- Develop the investigation skill, data analysis and communication skills
- Develop an attitude of sensible citizen with respect for environment and commitment to the wise use of resources,

Another issue is the traditional classroom teaching in which teachers has a dominant role. Teacher is considered a sole source of knowledge and role of students in this system is very passive. They have hardly any autonomy for them. They have to just follow their teachers. Teachers use traditional teaching skills and mostly focus on transfer of knowledge to students. According to Hodson (2003) student's involvement in learning process result in improvement of their knowledge, higher order skills and attitude towards science.

Examination system is also issue in present curriculum. This mostly demands on transmission of facts. Present examination system pressurized teachers to cover the content in a limited time at the cast of students learning. This system encourages memorization of facts.

In present curriculum practical work is not authentic. In present curriculum practical work is a set of routine exercise of pre-decided answers. Practical work is often

overlooked because of its time consuming nature and less weight age in board examinations. According to Wallace and Loudon (2002) quality practical work is a bridge between school science and real science. Quality of science education is directly proportional to quality of practical work. Good quality of practical means good quality of science education.

According to experts curriculum in Pakistan should be based on science technology society (STS) approach because this approach has potential to make science curriculum relevant to students. The vision of this approach is to develop a nation of scientifically literate citizens.

Experts believe that objectives of teaching of physics given in curriculum areas of developed countries like Malaysia, U.K and U.S.A. Experts suggest that following objectives must also be included in Pakistani curriculum

- To equip students with market-oriented knowledge of physics.
- To make them creative and logical thinker.

2.13 Causes of Poor-Quality Learning Out Comes

Learning outcomes are statements that describe what participants of a particular course will learn at the end of that course. Learning outcomes are like GPS navigation system. If once a location is fed in GPS system it will lead the driver throughout its journey to its destination. Even in if the driver takes a wrong turn GPS system will inform him and will help him in coming on right track. Learning out comes help teachers and students in achieving objectives of respective program or course. They keep them on right track.

Poor quality of students learning outcomes for physics at secondary level is a matter of great concern. This poor quality of learning outcomes for physics at secondary level indicates poor standard of physics education. Majority of students

spending years in school did not learn even basic skills of physics. Experts have identified various factors involve in poor quality of students learning outcomes of physics. Some of them are

2.13.1 Teacher's inappropriate subject knowledge. Learning outcomes cannot be achieved without qualified and skilled teachers. The personal and professional development of physics teachers has great impact on students learning. According to the findings of research conducted by J. Metzler & L.woessmann (2010) teacher's subject and pedagogy knowledge has significant effect on student's academic achievements. They find that one standard-deviation increase in teacher's subject knowledge raise student's achievement about 10 percent of a standard deviation. Teachers are very important pillar and key performer in education system. They need to be properly equipped because students have many intentions other than education. Qualified teachers and skilled teachers motivate students for study and impart conceptual education to them.

An untrained physics teacher is like a soldier who has gun but he doesn't know who to use it. Ibad Ashraf et al (2015) argued that one of the barriers in quality education of physics is untrained teachers. According to Economic survey of Pakistan (2002) defective curriculum, dual education system, overcrowded classrooms and poor quality of teachers are responsible for low standard of education in Pakistan.

2.13.2 Need to articulate clear and achievable learning goals for physics. Learning goals for physics describe a direction for learning of physics. Learning goals of physics sets the target of knowledge, skills and attitudes for physics students. Teachers made their decision for teaching on the basis of learning goals. Clear and achievable learning goals for physics provides a better framework for curriculum and course design and makes assessment straight forward. Learning goals must be clearly

understood by teachers. According to the report of HEART (2012) clear and achievable learning goals are very important for quality education but most of the countries do not have such learning goals. For example, there are language textbooks but teachers are not taught how to instruct students.

2.13.3 Overambitious curriculum of physics. It is observed that in developing countries physics students did not get much from schools. Researches show that after year of schooling students did not learn even basic skills required for physics. The pace of curriculum is much faster than pace of students. The gap between curriculum expectations and student's mastery is a matter of great concern. Pakistani curriculum expects from a student of grade first to have mastery in single digit addition. But according to a survey of LEAPS 65 % of third grade in Punjab could perform single digit addition**.** In the same way curriculum expect that a third-grade student can add fractions but only 19 % students can do it. The LEAPS study reports that typically children are three to four year below from curriculum. Educationists consistently pointed out the many countries have over ambitious curriculum (Crouch & korda, 2009) because of overambitious curriculum many students left behind stay behind forever. The report of HEART (2005) also point out that overambitious curriculum must be addressed to achieve learning out comes.

2.13.4 Home support. Generally, the proper learning environment for physics students is considered the sole responsibility of schools but role of parents and community in this regard cannot be ignored. Parents, brothers, sisters and other adult family members significantly contribute in improving academic performance of child in physics. According to Ganzalez-pienda et al (2002) without parent's support for students is it is very difficult for a teacher to properly teach his students. According to Khan and Zubairi (1999) parent's interaction with their children

depends upon their education and income. In another research Okpala and Smith (2001) revealed that economic circumstances of parents are significantly correlated with academic achievements of their children. Voorish (2003) argued in his studies that by parent's involvement students do their homework regularly and perform better in schools. In Pakistan literacy rate is low and poverty rate is high that's why students are not getting much support from their parents in their academics. This lack of parental support created many problems for child and school. If parents are educated then they have better understanding of their child and they can help him at home especially at early ears oh his/her education.

2.13.5 Tremendous diversity. In a classroom all students are not same in all aspects. Some are quick learner then other, some students are more coordinated then others, some have sharp memory than other, some are physically more fit then others etc. These differences are known as diversity. Diversity does not confine to some abilities. Parent's education, father's income, parent's occupation and some other factors also contributes to diversity. Diversity is a great barrier to quality learning. Students come in classroom with diverse back ground. Some students requite more support and attention especially those having marginalized. These students should not be neglected. In Pakistan student diversity is not acknowledge as a concern (Faisal Bari, Dawn news, 2020). Teachers in Pakistan face many challenges due to diversity. They need support to overcome these challenges. Efforts are required to purposefully train our teachers to deal with the issue of diversity in class and school.

2.13.6 Inappropriate assessment. According to Rehmani (2003) in Pakistan teachers teaches for testing not for learning. The assessment system encourages the memorization. Consequently, learning outcomes are absolutely ignored. Shah and Afzaal (2004) highlighted in their research that questions in examinations are often

repeated and selected material is tested again and again in our examination system. This leads toward selective studies. This helps student to get good marks with little or no understanding of subject.

Assessment is an integral part of pedagogy which determines the level of learning of students. Without quality assessment quality education is a dream.

2.14 Challenges in Implementation of Practicum at Secondary Schools

Practicum is very important in teaching and learning of science especially at secondary school level. According to NSTA (2007) laboratory plays very important role in effective teaching of science. Practicum encourages accurate observation, makes phenomenon more real and promotes reasoning method of thought. Practicum expands knowledge of a learner and helps him to understand world around him. Good implementation of practicum work is very helpful in development of understanding of students. It is common observation that practicum work is almost ignored and in not properly implemented in many countries of the world. There are many factors responsible for this some of them are

2.14.1 Equipment and facilities related issues. Practicum is very important component of science education and plays a very important role in understanding of scientific principles (Haftein & Noaman 2007).According to findings of research conducted by Muhammad Naeem Awan there is shortage of apparatus school laboratories in Pakistan. The same fact was also highlighted by Dawn news paper in a article published on March 6, 2011. Due to this shortage of apparatus teachers face difficulties in teaching

2.14.2 Separate laboratory room. Laboratory has same role in science education which a kitchen has in cooking or a garden has in gardening. Laboratory

has a pivotal role in laying base for science education. In many countries single laboratory room is used for all science education. In this case time cannot be allocated to each class for practical activities.

The findings of research conducted by Adedaya (2015) revealed that lack of separate laboratory for physics practical affect the attitude of students for practicum work of physics. In Pakistan many schools do not have separate laboratories for physics in some cases separate laboratories are available but their size is not proportional with number of students.

2.14.3 Overcrowded classrooms. The condition of government schools in Pakistan is very poor. No serious efforts are made to improve standard of educations in Pakistan. In Government schools classes are overcrowded. The situation in most of private schools is also not very much satisfactory. The main reasons for these overcrowded class rooms are increase in population and limited budget. According to Perveen Khan & Muhammad Iqbal (2012) there are 70 to 120 students in a class. Carlson (2000) find in his research quality learning is not possible in overcrowded class rooms. Shah and Inamullah (2012) also find in their studies that overcrowded class rooms have a negative effect on students learning.

Overcrowded class rooms create problems of proper seating arrangement and discipline in class. Teacher cannot pay attention to teach and every student and can't help the weak students. In overcrowded class rooms biodiversity crosses the acceptable level which makes teaching more difficult. According to Johnson (2011) with smaller students teacher ratio a teacher can pay more attention on students have sufficient time to check the performance to each and every student

2.14.4 Teacher's motivation. Teacher's motivation plays very important role in teaching and learning. Teacher's motivation is also a very important factor in

implementation of practical work. Teachers who are motivated can find ways for practical work in with limited resources and teachers who ate not motivated will not implement practical work with sufficient resources. Practicum is a very tough job and demands a lot of hard work by teachers. A teacher can fulfill this demand of hard work only when he is motivated. In Pakistan teachers are not motivated. They don't put their full effort for practicum.

2.14.5 Time allocation for practicum. Proper allocation of time for practicum work is very necessary. Without proper allocation of time, practicum work cannot be properly implemented because teachers and students need enough time to carry out practical work Generally instead of proper allocation of time for practicum work a 30 to 40 minutes lessen period once in a week is used for practicum work which is not enough. Because out of this one period approximately all time is consumed in practicalities of the task and no time is left for discussion of ideas behind phenomenon. According to Millar and Abrahams (2008) during a practicum class teachers consumed most of the time in giving instructions, collecting equipment and manipulating data with very less or no time left for discussion with students for supporting the development of their knowledge.

12.14.6 The need of laboratory assistant. A laboratory assistant plays very important in practicum work. Without him laboratory work cannot be implemented properly and effectively. Qualified and trained laboratory assistants have detailed knowledge of practicum work and they are very helpful in managing the work load of teachers in laboratory. Laboratories assistants are not only for distribution and collection of equipments and to prepare tea for teachers. According to Kaping ei and Kimeli (2014) effective practicum work required qualified and trained laboratory assistant. Unluckily in Pakistan qualified and trained laboratory assistant are not

available and teachers have to play role of laboratory assistant. If some where laboratory assistant is available he is engaged in other duties and not freed for his duties of lab assistant. This is a great barrier in proper and effective implementation of practicum..

12.14.7 Assessment related issues. According to current practices of assessment of practicum assembling of apparatus and measurement taken by students are assessed during practicum examination. Though these skills are important but only their assessment is not enough. For proper assessment some more dimensions of learning should be assessed. According to studies carried out by Doran, Lawren & Helgeson (1994) many science educators assess only some basic skills during practicum examinations.

According to Yung (2001) many teachers lacks experience in assessment .They can't assess understanding of student's properly. As a result grade awarded to these students do not represent their true understanding and performance of practicum. According to Giddings and Frasaer (1998) the achievements of objectives of science practicum depend a lot on mode of assessment. They also argued that mode of assessment also influence teacher's teaching method.

12.14.8 Students attitude toward practical work. According to findings of some studies student's attitude toward practicum is not very positive. They are not motivated for practicum. According to Alam & Farid (2011) students attitude play very important role in motivation of teachers. If teachers are not motivated how they can teach effectively? Students often scared from practicum and show annoyance during physics practical class. They prepare notebooks for theory classes but show reluctance for practical notebooks. This attitude of students increases the momentum against implementation of practicum. According to studies carried out by Viljaranta et

al (2014) there is a direct relation between student's interest and their academic achievement in science education. Student's motivation is very important because motivated students in turn motivate their teachers which as a result deliver quality practicum.

2.15 Different Methods of Instructions for Physics

During mid of 20th century science educators started raising questions about effectiveness of lecture method especially for science subjects like physics. It was observed that by traditional lecture method many students of physics did not understand even basic concepts like velocity, acceleration and momentum. This concern was taken by the researchers. Researchers found traditional lecture method did not full fill the demands of physics. In this method students have a very passive role. Researchers start efforts to develop some new teaching strategy that can replace the traditional lecture method.

2.15.1 Physics by Inquiry.

Lillian McDermolt (2001) and her group found that traditional lecture method is ineffective for physics teaching. They identified students' difficulties in learning of physics by lecture method through paper and pencil test and by interviews. They also found that misconceptions developed by lecture method at introductory level remain at advance level and are not overcome.

McDermot (2001) and her group developed a new curriculum for instructions of physics which was named as "Physics by inquiry". According to McDermott (2001) this approach is a better way for teaching of physics as it involve students physically and mentally in learning process. By this approach students develop the concept on their own and teacher just plays the role of facilitator. According to this approach students first realize their common mistakes then through reasoning they are

helped to resolve those mistakes. The main focus of this curriculum was building of conceptual understanding.

Initially this curriculum was implemented for pre-service and in-service training of teachers. Later on this curriculum was implemented at school level and college level. This curriculum was not over loaded with factual information like traditional curriculum.

Physics by inquiry is a laboratory based approach in which students collectively in groups perform experiments followed by exercises and questions. Students start by simple observations and perform experiments to collect data. This data help them in developing their concepts. So in physics by inquiry approach students precede step by step through experimentation and reasoning. Here teacher did not deliver a lecture he just ask open ended question to students that encourages students. Hypothesizing, collections of data, analyzing data and making predictions have been integrated in this curriculum. McDermott (2001) have presented this approach in the form of book 'Physics by inquiry". There are two volume of this book and these two volumes cover most of the fundamental concepts of physics.

2.15.2 Real Time physics.

During 1980 physics education researchers start questioning about effectiveness of traditional laboratory work. This questioning shifts the paradigms of research in physics education from difficulties faced by students in learning to effectiveness of laboratory work. Ronald Thornton (1980) from Tufts university center for teaching of science and mathematics and David Sokoloff (1980) from the University of Oregon proposed a new program for teaching of physics. This program was given the name "workshop physics" as it is carried out in workshop setting. The "workshop physics" curriculum was different from traditional curriculum of physics.

According to this curriculum students not only perform experiment in workshop but also discuss their findings with their teachers and fellow students. Students collect and analyze data in workshop and present his/her findings.

Later on computer based tools were also developed. These tools allowed students to effectively collect and analyze data.

Together these computers based tools and physics workshop gives birth to “Real Time physics”. This new approach of teaching physics was quite different and realistic from traditional approach of physics. Real time physics is based on set of four volumes developed by David Sokoloff, Priscilla Laws, Ronald Thorton (2004). These volumes comprises of large number of physics activities specifically designed to collect, analyze and present data. For example the first volume has 12 sessions focusing on concept of mechanics. The main goals of real Time physics are that students can gain understanding of basic concept of physics and develop traditional laboratory skills.

With the introduction of MBL tools in this approach it become very popular.MBL tools stand for microcomputer-based laboratory tools. With the help of this tool students can observed graph produced.

A session of real time physics starts with predictions of students. A student made predictions about some physical phenomenon. After predictions made by a student he discuss these observations with a group of his fellow students. Then students test his predictions by experimentation. During experimentation students also use MBL tools. All activities in Real time physics are designed very carefully to address common misconceptions of students.

The effectiveness of Real Time physics has been measured by using specially designed test and it is found that Real Time physics is very effective in developing

understanding of students about physics' concepts.

2.15.3 Interactive Lecture Demonstrations.

The real time physics curriculum has been successfully implemented in many institutions of USA. But there were some problems with this curriculum. Firstly this curriculum requires large number of computers and laboratory space. This was not possible everywhere especially in those institute where students are in large number. Another problem with this curriculum was that its basic focus was conceptual understanding of students. This curriculum does not focus on mastery in laboratory skills which are very important in physics learning.

David Sokolof (1997) and his group at the University of Oregon developed a new approach for learning of physics. This approach was based on passive lecture method. Microcomputer-based tools were also the part of this research.

According to interactive lecture demonstration approach at first step students make predictions about what they expect to see in a experiment. At second step they discuss their predictions with their fellow students. At third stage students verify the predictions by experimentations. Researchers have found that that doing predictions is very help full in learning of students.

2.15.4 Investigative science learning environment (ISLE).

A drawback in instructional approaches discussed so for is that their basic focus is on conceptual understanding of students they do not focus on mastery in laboratory skills which are very important in physics learning. A physics course should also develop skills which are required at workplace while using knowledge of physics. The American Association of Physics Teachers (AAPT) also supports this argument. Physics education researchers found that there is a mismatch between knowledge and skills acquired by students and knowledge and skills required at

workplace. Traditional lecture method and Real time physics have nothing to do with basic skills which are very necessary for learning of physics. This let the researchers to work on developing an approach that focuses on basic understanding of concepts as well as necessary skills.

Eugenia Etkina, Van Heuvelen (2007) at Rutgers University developed an approach which is known as investigative science learning environment (ISLE).The focus of this research was not only conceptual understanding of physics but also to develop basic skills necessary for learning of physics. The ISLE curriculum mainly focuses on following skills (i) the ability to design an experiment (ii) the ability to collect data (iii) the ability to analyze data (iv) the ability to evaluate experimental predictions (iv) to represent knowledge in multiple ways. In ISEL cycle a topic is studied in three steps. In first step student make observations from a experiment and form a hypothesis on the basis of these observations. At second step he performs a testing experiment to check his hypothesis. If experiment does not verify his hypothesis he made some modifications in his hypothesis at this stage. At last step students perform application experiment to apply his ideas.

Assessment of ISLE approach made by Etkina(2007), show that this approach is very helpful in developing various skills in students. Which are very important for effective learning for Physics.

2.16 Learning Theories of Science Education

During twentieth-century educationists come out with several learning theories. These theories brought a revolution in learning of science. These theories explained who a student can learn effectively. These theories significantly affect teaching of science. Out of these theories three will be discuss here. These three theories are based on three paradigms which are behaviorisms, cognitivism and

constructivism.

Behaviourists believe that learning is linked with behavior of learner and main aim of education is modification in behavior. According to cognitivists, the behavior is linked with cognition and main aim of education is change in cognitive schemas. And according to constructivist learner construct their knowledge and main aim o0f education is to provide learners opportunities for construction of their knowledge.

2.16.1 Behavioral learning theory.

Behavioral theory of learning is a popular concept of learning. According to this theory a student learn his behavior by interaction with his environment. Primary concerned of behavioral theory is observable and measurable aspects of behavior. According to this theory all behaviors are learned from environment and inherited factors have very little effect on behavior.

Behaviorism helps teacher to understand how home environment and society impact on behavior of student. This theory motivates teachers to use environmental factors for learning of students. Behaviorism advocates the system of reward and punishment in class room, reward for desired behavior and punishment for inappropriate behavior. For example if teacher wishes to teach his student to work hard in studies he may award him a prize for some test achievement. Next time student will work hard to achieve reward again.

According to behavior theory learning is acquisition of new behavior base on environmental conditions. There are two types of conditions

(i) classical conditioning

(ii) operant conditioning

Classical conditioning stands for a learning process in which a biological stimulus is paired with a previously neutral stimulus. Operant condition stands for a learning

process which is based on reward and punishment.

According to behavior theory behaviors are not only learned but also unlearned. When a behavior becomes unacceptable it is replaced by some acceptable behavior. Many behavioral techniques are very successfully used in classroom teaching. Some of these techniques are contracts, reinforcement and extinction.

Ivan Petrovich Povlv is among earliest behaviorist. He performed several experiments on doge. On the basis of these dogs he presented concept of classical conditioning. Classical conditioning can be used in shaping behavior of humans

B.F Skinner was also among earliest behaviorist. He performed several experiments on mice. On the basis of these experiments he presented concept of operant reasoning. According to Skinner a person is a blank organism that has nothing to explain its behavior. The difference between classical conditioning and operant conditioning is that in operant conditioning human behavior effect environment while in classical conditioning human behavior does nit effect environment.

According to behavioral theory of learning, learning is basically a process of establishing a relationship between stimulus and response. This relationship is further elaborated by three laws which are law of readiness, law of exercise and law of effect. According to law of readiness a relation between stimulus and response will be stronger when element of readiness is present there..Therefore a teacher should make ready his/her students for learning before start of lecture. The law of exercise states the more frequent the stimulus-response relation, the more stronger the relation will be. A student will show a quick response to a problem to which he/she encounters frequently. The law of effect explains that when the relation between stimulus and response is followed by satisfaction it will make association more strong

2.16.2 Cognitive theory of learning.

Cognitive learning is an active style of learning. Cognitive learning focuses on absorption of knowledge rather than storage of information. Cognitive learning deals with potential of brain. The ability of brain to absorb or retain information by its mental process is called cognition. There is a clear difference between traditional learning and cognitive learning. Traditional learning mainly deals with memorization of facts. Traditional learning focuses on lower order thinking and it has nothing o do with higher order thinking. It has nothing to do with mastery in a particular subject. While cognitive learning on the other hand connects new information with existing knowledge of learner. Cognitive learning is very helpful in deepening memory of learner and retention of capacity. Cognitive learning deals with comprehension, memory and application of knowledge. As shown in Fig 15 (www.valamis.com)

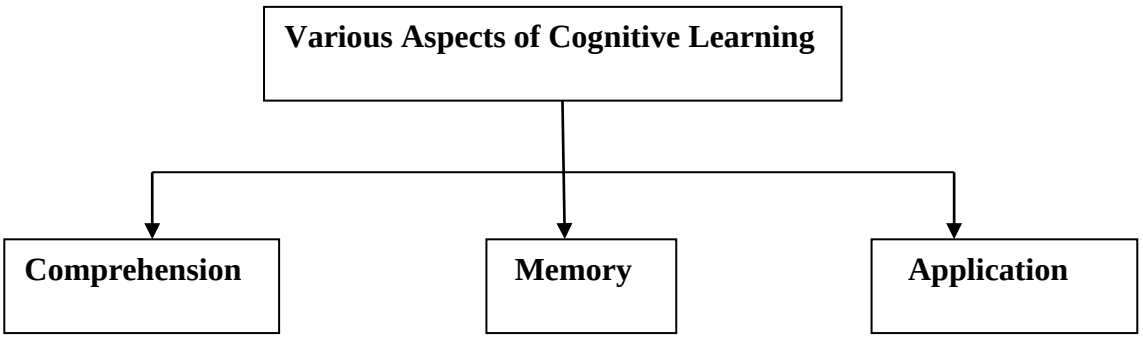

Figure 2.14: Various aspects of cognitive learning

Cognitive learning theory explains how external and internal factors influence on a mental process and affect the process of learning .According to cognitive theory of learning there will be difficulties in learning when cognitive process is not working smoothly.

Jean Piaget is one of the founder of cognitive theory of learning .According to him learning is basically relation between already existing information and new information. Piaget argued that a learner take starts with knowledge and experience

he/she has and enhance this knowledge and experiences. He further argued that there are three vital components of learning.

i. Accommodation**:** new knowledge

ii. Assimilation**;** arrangement of new knowledge in brain

iii. Equilibration**:** balancing between new knowledge and already existed knowledge.

David Ausubel made a clear distinction between meaning full learning and rote learning. According to him if learning material is closely linked with existing knowledge of the learner the learning will be meaningful for him. On the other hand it will be just memorization.

Cognitive learning has some very positive effects. It enhance learning, boosts confidence sand improve problem-salving skills of learner.

2.16.3 Constructivism theory of learning. Constructivism theory of learning claims that people learn by using the knowledge they have. People construct new knowledge and understanding on the basis of their existing knowledge. Constructivism is an epistemological view of learning rather than teaching. Constructivism posits responsibility of learning on students and argued that learning took place by active participation of learner.

Piaget stands among earliest philosophers of constructivist theory. According to Piaget learner's own actions play very important role in their cognitive development. The cognitive development is because of adoption of learners to the environment. Initially Piaget believes that learning is related to an individual and a individual can develop his cognition by analyzing and interpretation of facts but later on his believe was shifted from the learning as individual to learning with some social context.

Lev Vigotsky was also among earlier philosophers of constructive theory of learning. He believes that cognitive development was governed by learning process and learning process requires learner attention and participation. According to Vigotsky for cognitive development a learner should not only be internally active but he should also be actively linked with his surroundings. When a child cannot complete a task alone have some peer having slightly higher cognitive level then he can complete the task with the help of peer. Vigotsky emphasis more on social interactions for cognitive development in contrast to piaget who emphasis on individual's active participation in learning process.

According to constructivism theory the learning should be student center and teacher should play the role of facilitator. Constructivism demands for conducive environment. A proper constructivist learning environment is one in which

(i) Learners are challenged by questions and problems that generate cognitive conflict.

(ii) Students are appreciated for actively participating in learning process.

(iii) Students are appreciated for communicating with their teachers and fellow students.

Constructivism is not the name of single strategy. It is combination of several strategies with no specific composition. The composition of different strategies depends on need and requirement of learner. Some common themes of constructivism highlighted by different researches are following. Education should be student center, teachers is only a facilitator, role of teacher in classroom is very passive, learning depend on shared experiences, students should actively participate in hand on experiences, learner should effectively think on the problem under focus, knowledge is being constructed in social context, learner cannot construct understanding alone.

CHAPTER 3

Research Methodology

3.1 Introduction

This research was about Physics practicum at secondary level. The domains of this research were to explore how Physics practicum is performed and assess in secondary school laboratories and to find facts and challenges about this practicum. In this research data was collected by questionnaire and quantitative approach was used.

3.2 Research Design

According to Klassen (2012) a research design is a procedure that involves collecting of data, analyzing of data and reporting the results. A research design plays same role during conduction of research which a building design plays during construction of building. Research design helps a researcher to proceeds forward in a convenient way.

This research was descriptive. A descriptive research is one which is used to describe a situation. This type of research is helpful in deep understanding of situation and to find its solution.

Here survey method was used and data was collected from primary source by a self-a questionnaire.

This research was qualitative. Data obtained by questionnaire was analyzed by basic statistics and thematic analysis.

3.3 Research Instrument

Teachers have very important role in Physics practicum because they are on driving seat. They have the best information about Physics practicum in laboratories. So, researcher decided to collect data from them about Physics practicum by a self-design questionnaire. According to Bill Gillham (2008) questionnaire is very

wonderful research tool because it saves time and many. He also argued that by questionnaire we can get information from lot of people very quickly and respondent can complete the questionnaire when it suits them without pressure of immediate response. The questionnaire for this research is adapted from the research "Practice and Challenges Facing Practical Work Implementation in Natural Science Subjects at Secondary Schools" conducted by Abebe Adugna Chala (2019). Prior permission was taken from the researcher. The questionnaire is based on likert scale with five points. Likert scale is most widely used psychometric scale. It is used to measure attitudes of people. A likert scale allows respondents to express how much they agree or disagree with a particular statement. It does not restrict respondent to answer in yes or no. Generally, a five-point Likert scale is used.

Table 3.1

Likert scale with five points

Strongly disagree	Disagree	Undecided	Agree	Strongly agree
(1)	**(2)**	**(3)**	**(4)**	**(5)**

The questionnaire consists of twenty-five close-ended questions and two open-ended questions. The questionnaire was divided into six sections. First section is about awareness and implementation of standards and benchmarks set in National Curriculum of physics 2006, second one is about preparation practices of practicum examination, third about assessment practices of practicum, fourth about apparatus, facilities and teacher training for practicum, fifth about attitude of stake holders of Physics practicum and six section consist of two open-ended questions about implementation of Physics practicum. Validity and reliability of tool was developed

before data collection.

3.4 Verification of Tool

3.4.1 Validity of research tool. Validity of an instrument means the degree to which it measures what it supposed to measure. It is very important characteristic of a research tool. In order to check validity of questionnaire researcher approached to six experts of relevant field.

Researcher personally visited A.I.O.U, Arid and Agriculture University Rawalpindi, International Islamic University and NUML Islamabad to meets these experts. Researcher thoroughly explained the objectives of research and each statement of questionnaire. All experts thoroughly analyze questionnaire and check various aspects of validity. They check face validity, construct validity, content validity and criterion validity and give valuable advices. Changes were made in questionnaire in light of their suggestions.

The questionnaire is attaches in Annexure I.

3.4.2 Pilot Testing. Pilot testing is very important stage in a research project. It is basically rehearsal of main research on small scale. Though it is time consuming and takes much efforts but it is very help full in improving the research design and save a researcher from back peddling.

For pilot testing of this research 20 teachers were selected from population outside the circle of sample. Researcher personally visited them. They were asked to fill the questionnaire and highlight any sentence or word creating an ambiguity or confusion. Researcher also discussed the questionnaire with respondent to know their views about questionnaire. In light of this feedback changes are made in language of two statements.

3.4.3 Reliability of the research tool. Reliability refers to the degree to which result obtained by a research tool is replicated. Though reliability contributes in validity but only reliability is not sufficient for validity. A research tool is a key part of any research. It is like a heart of research. If research tool is not reliable than data collected from such a tool will be fake and conclusion drawn on the basis of such fake data will not be reliable.

There are different types of reliability

i. Test-rest reliability

ii. Interrater reliability

iii. Parallel forms reliability

iv. Internal consistency reliability

Here internal consistency reliability of questionnaire was measured. Internal consistency reflects how much items of a questionnaire measure various aspects of the same construct. This type of reliability can is calculated without repeating test. A wide variety of statistical test are available for internal consistency, here Cronbach's alpha was used. First the questionnaire was administered in a group. At second stage the data from administered questionnaires was shifted to a coding sheet. For scoring the questionnaire a numeric code was assign to each response in following way.

Strongly agree	5
Agree	4
Undecided	3
Disagree	2
Strongly disagree	1

At third stage value of Cronbach's alpha was calculated.

Table 3.2

Table of Cronbach's Alpha

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

3.4.4 Controlling threats for validity. It is very important to ensure maximum validity for a research. There are several threats for validity that a researcher may encounter during his research and efforts are required to overcome these threats. Researcher made lot of efforts to ensure validity of research.

Firstly, sample was selected randomly. This help to overcome selection bias. If sample is not selected randomly then there is a possibility that people of different characteristics become part of sample that may affect research. Selection of suitable sample is base of authentic research. Secondly size of sample as kept large as much as possible. Thirdly sample was selected at the end of academic year because this is the best time to give views about academic activities and response of all participants is recorded during same academic year. Fourthly respondents response differently when they know they are participating in a survey .This fact was minimized by allowing them not mentioning their identity on questionnaire, Fifthly researcher follow respondent to minimize attrition rate.

3.5 Item total correlation

Table 3.3

Table of internal consistency

Factor	Number of items	Cronbach's alpha
Awareness and implementation of standards and benchmarks set in National Curriculum .2006	05	0.9
Preparation practices of Physics Practicum in schools	05	0.85
Assessment practices of practicum examination	05	0.84
Apparatus, facilities and teachers training for Physics practicum.	05	0.84
Attitude of stake holders for physics practicum	05	0.85

3.6 Population

In research population is defined as a group of individuals, institutions or objects having common characteristics that are interest of researcher. In this research the population of study comprises of secondary school physics teachers of Federal Government Educational Institutions (Cantt/Garrison) included in Rawalpindi, Wah, Chaklala. These three regions consist of 83 secondary institutes. According to

directorate of Federal Government Educational Institutions (Cantt/Garrison) there were about one hundred and eighty-three secondary school physics teachers serving in these institutes.

Table 3.4

Region Wise Distribution of Schools and Teachers

S.No	Regions	Number of schools	Number of teachers
1	Rawalpindi region	30	65
2	Chaklala region	31	68
3	Wah region	22	50

3.7 Sampling Technique

The process of selection of accurate representation from a population of interest is called sampling. Generally, a population consists of many individuals. It is very difficult for a researcher to collect data from each and every individual of population. To overcome this problem sampling technique is used. Sampling save time and resources and make research easier. A sample represents whole population. There result obtained by sample will be generalized for whole population. As this research was carried out during the pandemic of Covid-19 and all schools were closed, so purposive sampling technique was used. According to this sampling technique, sample is selected on the basis of convenience of researcher. This sampling technique is a form of non-probability sampling.

Out of one hundred and eighty-three, 125 secondary school teachers are selected as a sample.

Table 3.5

Sample

S.No	Number of schools	Number of teachers	sample
1	83	183	125

3.8 Data Collection

Data collection was started after establishing validity and reliability of research tool. Principal of respective institute were taken into confidence before interaction with teachers of their institute. In many cases researcher visited school in school hours and questionnaire was distributed to teachers personally. Researcher thoroughly explained motives behind the research give general guide lines for filling up the questionnaire.

3.9 Data Analysis

Data obtained by questionnaire was analyzed by basic statistics and thematic analysis. Data obtained by closed ended questions data was analyzed by finding percentages of different responses and data obtained by open ended questions was analyzed by thematic analysis. For thematic analysis thorough reading of data was done. Codes were generated by researcher to highlight the pattern in the data. The similar highlighted patterns were used to develop themes.

3.10 Research Ethics

Research involve human beings has many ethical implications. These implications must not be overlooked (Oliver, P. 2010). If these ethical implications are overlooked they may cause many complications at later stages of research.

Respecting the research ethics, researcher has given a written consent form to respondents for questionnaire. In this form purpose of research and usage of finding were very clearly explained to the respondents. Respondents were also assured about their anonymity.

3. 11 Delimitations of Study

This study was delimited only for subject of physics. Only practical work of physics subject was investigated. This study is limited to secondary level practical work. Data was collected only from teachers of Federal Government Educational Institutions (Cantt/Garrison) of Rawalpindi, Chaklala and Wah region. In this study assessment of Physics practicum is made on the basis of national curriculum of physics 2006.

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CHAPTER 4

Data Analysis and Interpretation

The study was about evaluation of preparation and assessment practices of Physics practicum at secondary level. This was a descriptive research. A questionnaire was used to collect data from physics teachers of secondary level. The questionnaire consist of 25 closed-ended questions about five different aspects of topic of research. These aspects are awareness and implementation of standard and benchmarks set in national curriculum of physics 2006, preparation practices of physics practicum in schools, assessment practices of practical examination, apparatus facilities and teachers training for physics practicum and attitude of stake holders for physics practicum. This questionnaire also has two open ended questions. The first open-ended question was about barriers for implementation of Physics practicum and second open ended question was about suggestions by teachers for proper implementation of Physics practicum. First data is evaluated with the help of percentages. For analysis of open ended questions researcher carefully read all the responses and highlighted the major ideas provided by respondents. Finally researcher made major themes with the help of these sub themes. These major themes are presented in tabular form for better understanding of facts about Physics practicum.

4.1 ANALYSIS OF CLOSED-ENDED ITEMS IN QUESTIONNAIRE

First closed ended questions are analyzed and results are presented in tables. Here percentage was calculated to find out responses for different options of a statement. This is done because it was a exploratory study and there was no comparison of mean score is being made. That is why data is explained with the help of percentages for various options of a statement.

Table 4.1

Teachers have awareness about standard and benchmarks set in National curriculum of physics 2006.

	SA	A	UD	D	SD	Total
Responses	18	51	-	21	12	102
Percentage	18	50	-	20	12	100

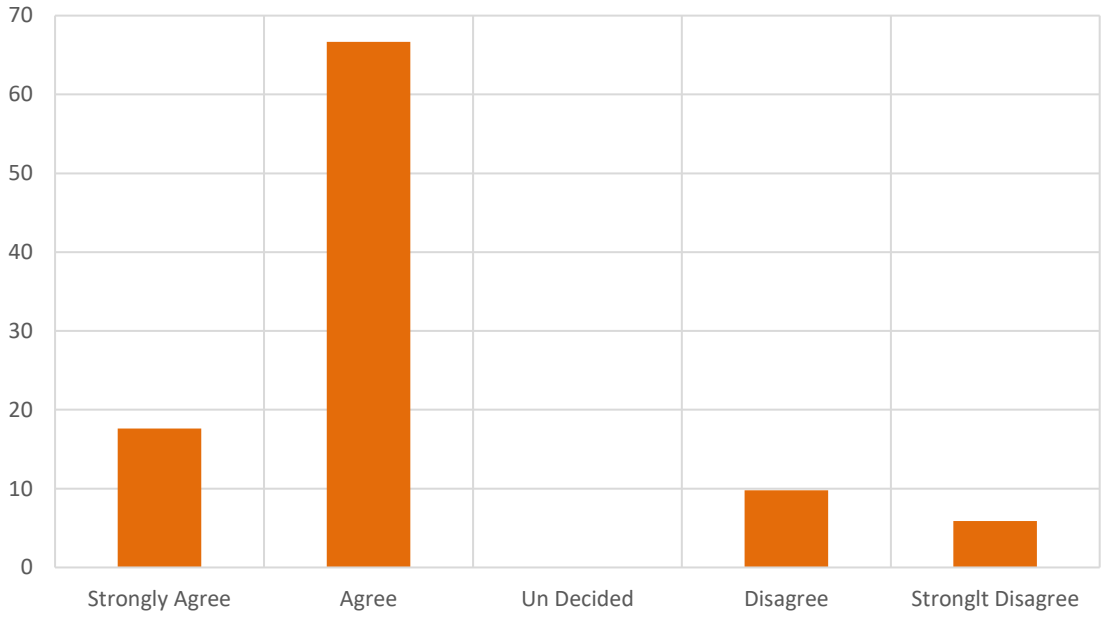


Fig 4.1: *Teachers have awareness about standard and benchmarks set in National curriculum of physics 2006.*

Fig 4.1 shows analysis of responses from 102 teachers. Out of 102 teachers 18% showed strongly agree response for statement and 50% showed agree response for statement. No one stood undecided. While 20% showed disagree response and 12% showed strongly disagreed response. The overall response of teachers for statement "Teachers have awareness about standard and benchmarks set in National curriculum of physics 2006." is agreed.

Table 4.2

Physics practicum work at secondary level meets with the standards set in National curriculum of physics 2006.

	SA	A	UD	D	SD	Total
Responses	10	27	15	35	15	102
Percentage	10	26	15	34	15	100

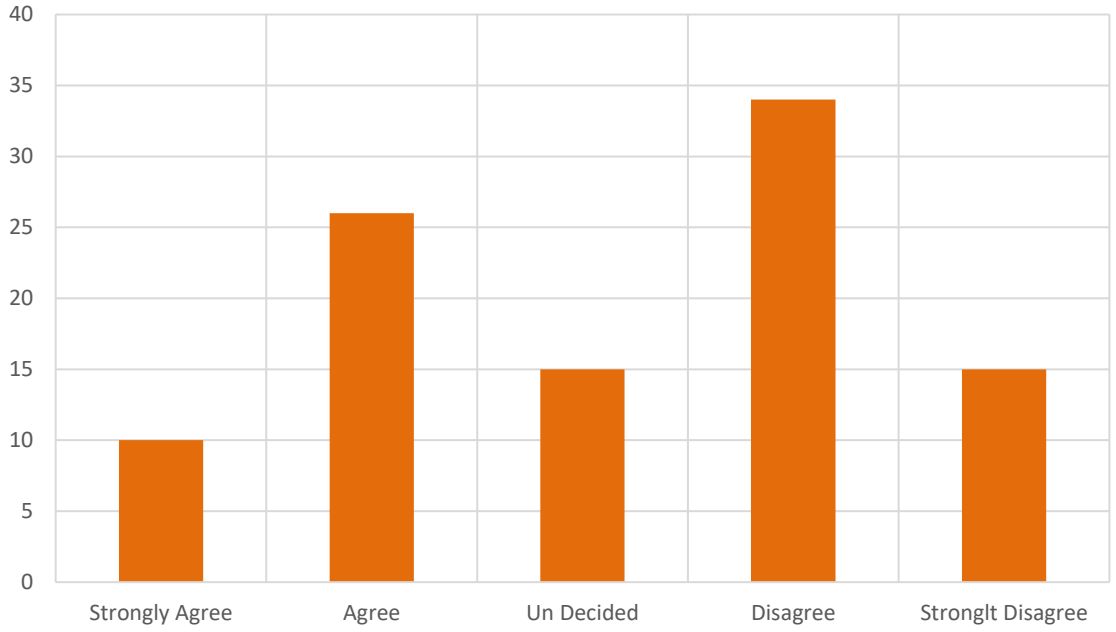


Fig: 4.2: *Physics practicum work at secondary level meets with the standards set in National curriculum of physics 2006.*

Fig. 4.2 shows analysis of responses by 102 teachers. Out of these 102 teachers 10% showed strongly agree response for statement and 26% showed agree response for statement. 15% stood undecided. While 34% give disagree response and 15% give strong disagree response. The statement "Physics practicum work at secondary level meets with the standards set in National curriculum of physics 2006." received an overall disagreed response from respondents.

Table 4.3

Learning objectives set in National Curriculum of Physics 2006 are achievable.

	SA	A	UD	D	SD	Total
Responses	15	50	12	15	10	102
Percentage	15	49	12	14	10	100

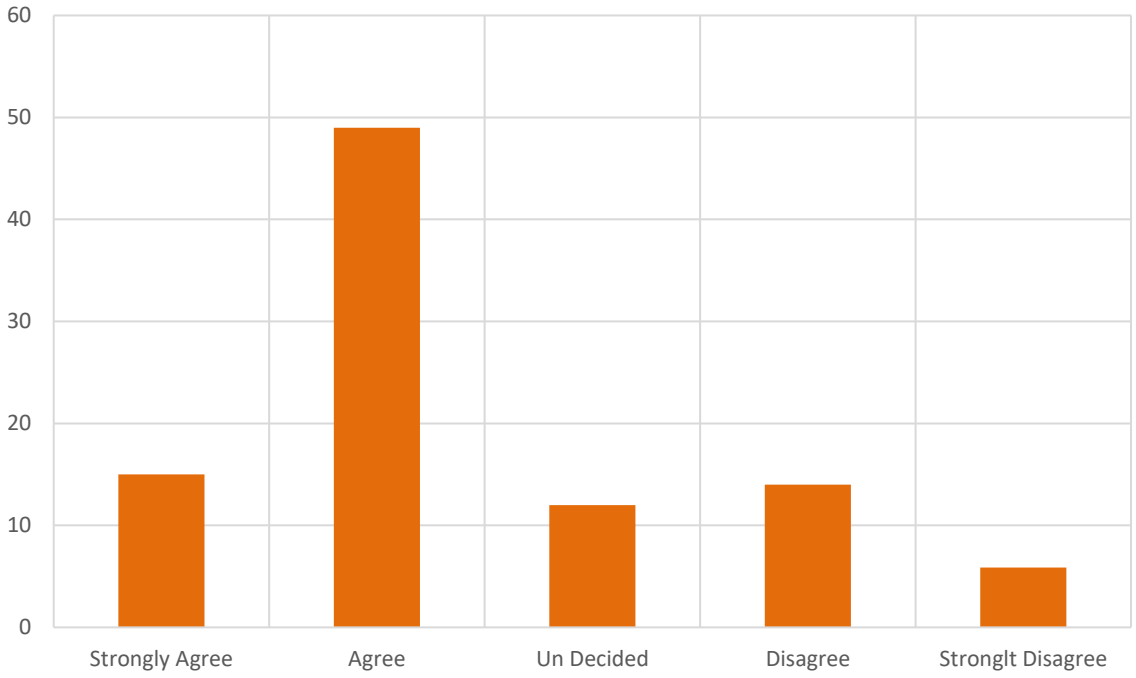


Fig 4.3: *Learning objectives set in National Curriculum of Physics 2006 are achievable.*

Fig 4.3 shows analysis of responses from 102 teachers. Out of 102 teachers 15% showed strongly agree response for statement and 49% showed agree response for statement. 12% stood undecided. While 14% showed disagree response and 10% showed strongly disagreed response. The overall response of teachers for statement "Learning objectives set in National Curriculum of Physics 2006 are achievable." is agreed.

Table 4.4

Physics course content help in achieving the learning objectives given in national curriculum of Physics, 2006.

	SA	A	UD	D	SD	Total
Responses	08	23	11	45	15	102
Percentage	08	22	11	44	15	100

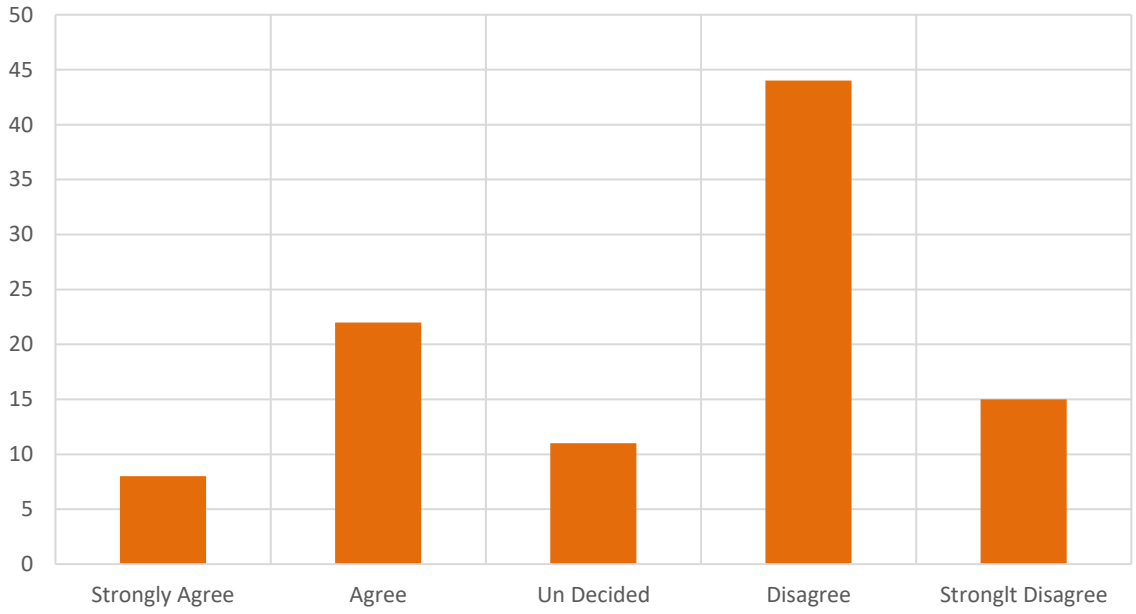


Fig 4.4: *Physics course content help in achieving the learning objectives given in national curriculum of Physics, 2006.*

Fig 4.4 shows analysis of responses from 102 teachers. Out of 102 teachers 08% showed strongly agree response for statement and 22% showed agree response for statement. 11% stood undecided. While 44% showed disagree response and 15% showed strongly disagreed response. The overall response of teachers for statement "Physics course content help in achieving the learning objectives given in national curriculum of Physics, 2006." is disagree.

Table 4.5

Physics practicum is implemented in secondary school laboratories according to spirit of National curriculum of Physics 2006.

	SA	A	UD	D	SD	Total
Responses	11	30	-	49	12	102
Percentage	11	29	-	48	12	100

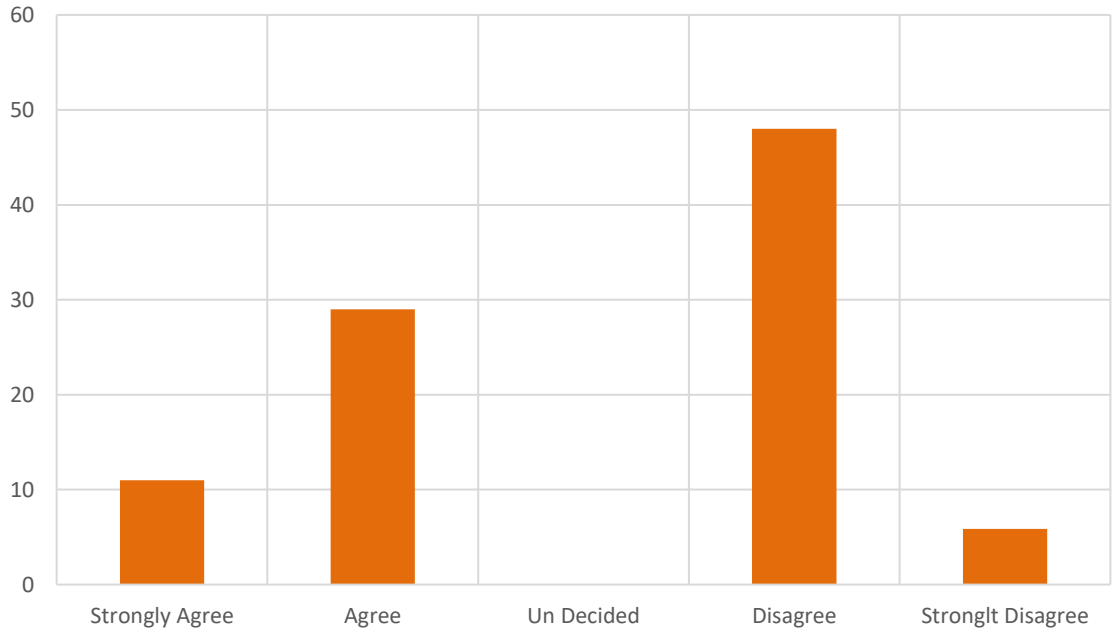


Fig 4.5: *Physics practicum is implemented in secondary school laboratories according to spirit of National curriculum of Physics 2006.*

The analysis of data in Fig-4.5 included the responses of 102 Physics teachers. Of those 11% subjects 'strongly agreed' to the statement, while 29% subjects 'agreed'. The response of 'undecided' subject was nil. The 'disagreed' response was 48% and response regarding 'strong disagreement' was 12%. The crux of the analysis is that the statement received 'disagreed' response from majority of respondents. The magnitude of disagreed response is about 60%.

Table 4.6

Students are given access for apparatus in laboratory.

	SA	A	UD	D	SD	Total
Responses	12	30	10	40	10	102
Percentage	12	29	10	39	10	100

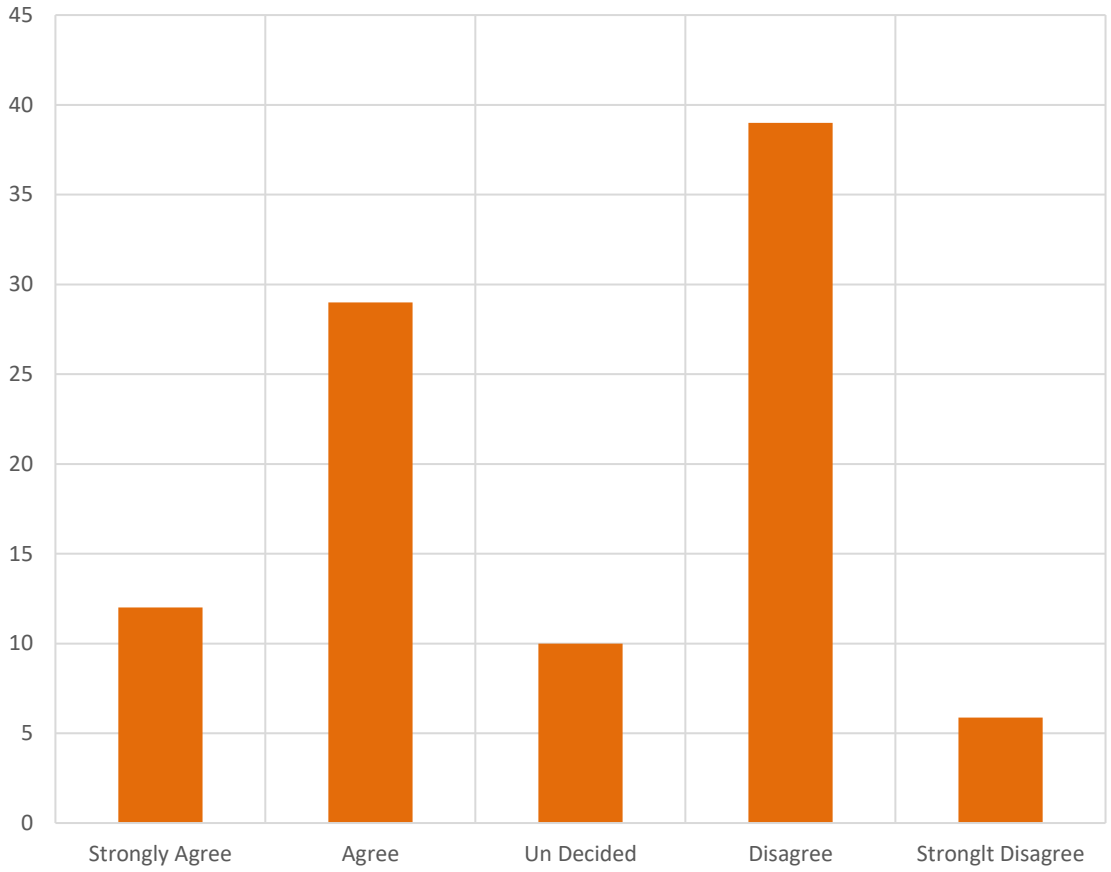


Fig 4.6: *Students are given access for apparatus in laboratory.*

Fig. 4.6 shows analysis of responses by 102 teachers. Out of these 102 teachers 12% showed strong agreenes for statement and 29% showed agreenes for statement. 10% stood undecided. While 39% give disagree response and 10% give strong disagree response. The statement “Students are given access for apparatus in laboratory” received an overall disagreed response from respondents.

Table 4.7

Students are given opportunities to perform Physics practicum independently.

	SA	A	UD	D	SD	Total
Responses	15	25	17	30	15	102
Percentage	15	24	17	29	15	100

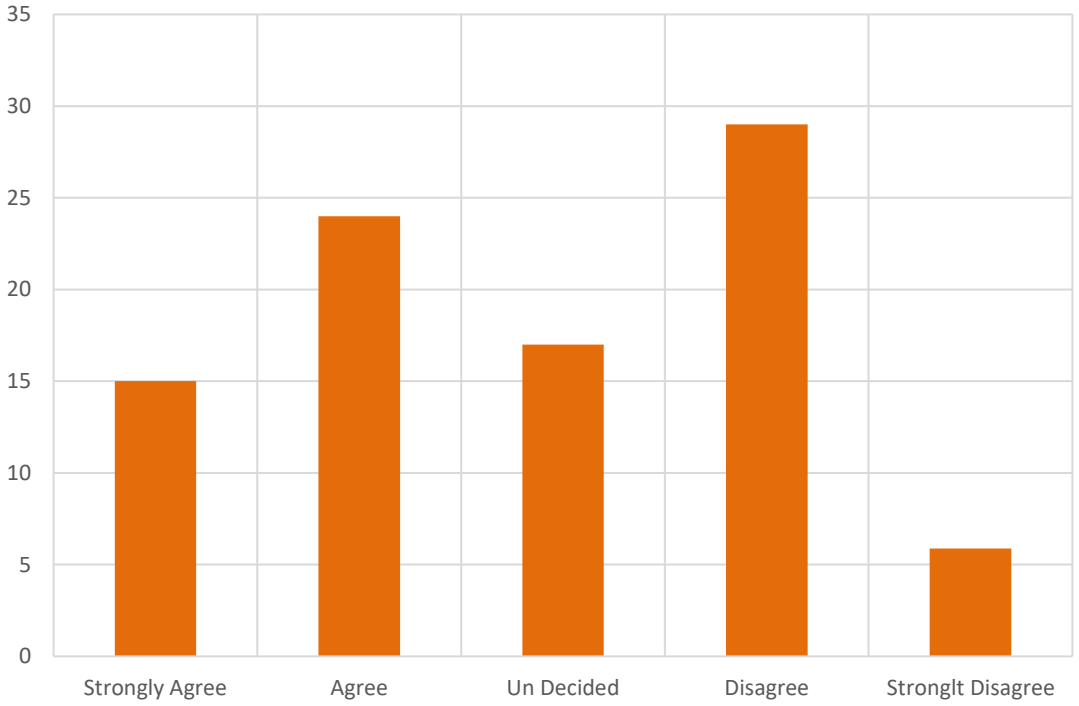


Fig 4.7: *Students are given opportunities to perform Physics practicum independently.*

The analysis of data in Fig-4.7 included the responses of 102 Physics teachers. Of those 15% subjects 'strongly agreed' to the statement, while 24% subjects 'agreed'. The response of 'undecided' subject was 17%. The 'disagreed' response was 29% and response regarding 'strong disagreement' was 15%. The crux of the analysis is that the statement received 'disagreed' response from majority of respondents. The magnitude of agreed response is about 75%.

Table 4.8

Teachers encourage students for asking questions.

	SA	A	UD	D	SD	Total
Responses	08	50	09	22	13	102
Percentage	08	49	09	21	13	100

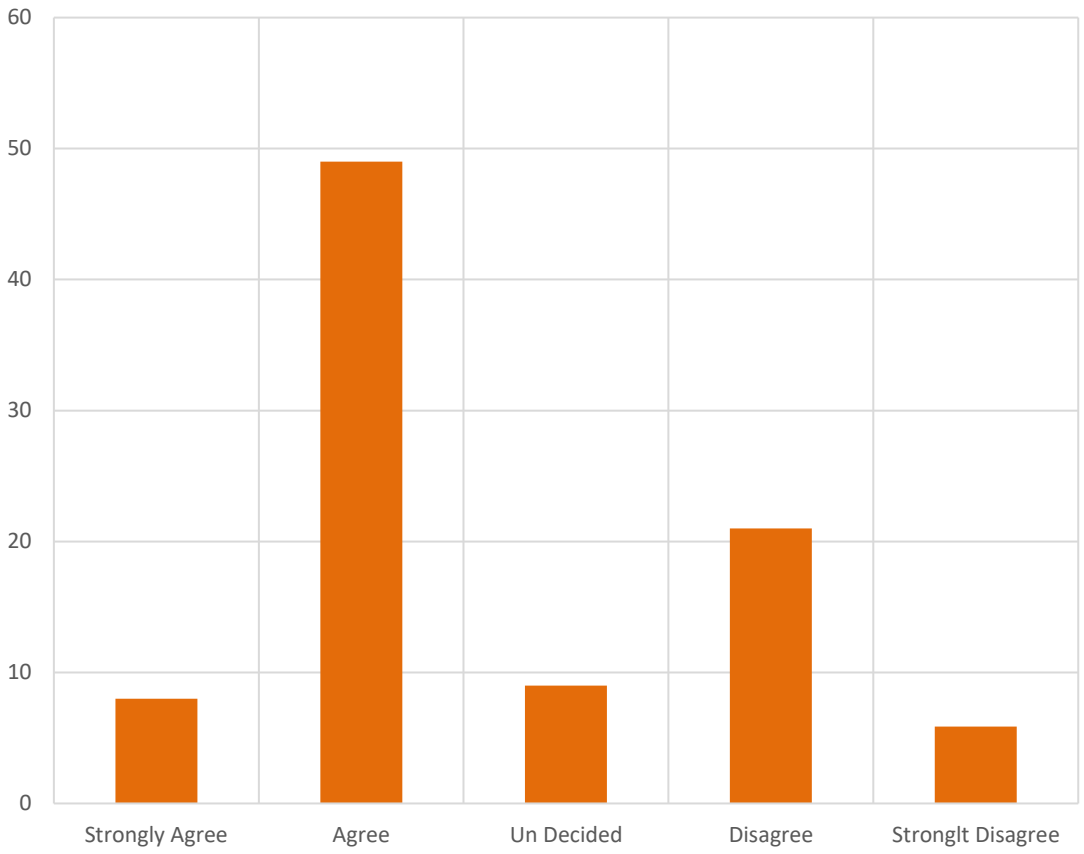


Fig: 4.8 *Teachers encourage students for asking questions.*

Fig 4.8 shows analysis of responses from 102 teachers. Out of 102 teachers 08% showed strongly agree response for statement and 49% showed agree response for statement. 09% stood undecided. While 21% showed disagree response and 13% showed strongly disagreed response. The overall response of teachers for statement "Teachers encourage students for asking questions" is agreed.

Table 4.9

Teachers regularly take students to laboratory for practicum..

	SA	A	UD	D	SD	Total
Responses	16	31	-	51	04	102
Percentage	16	30	-	50	04	100

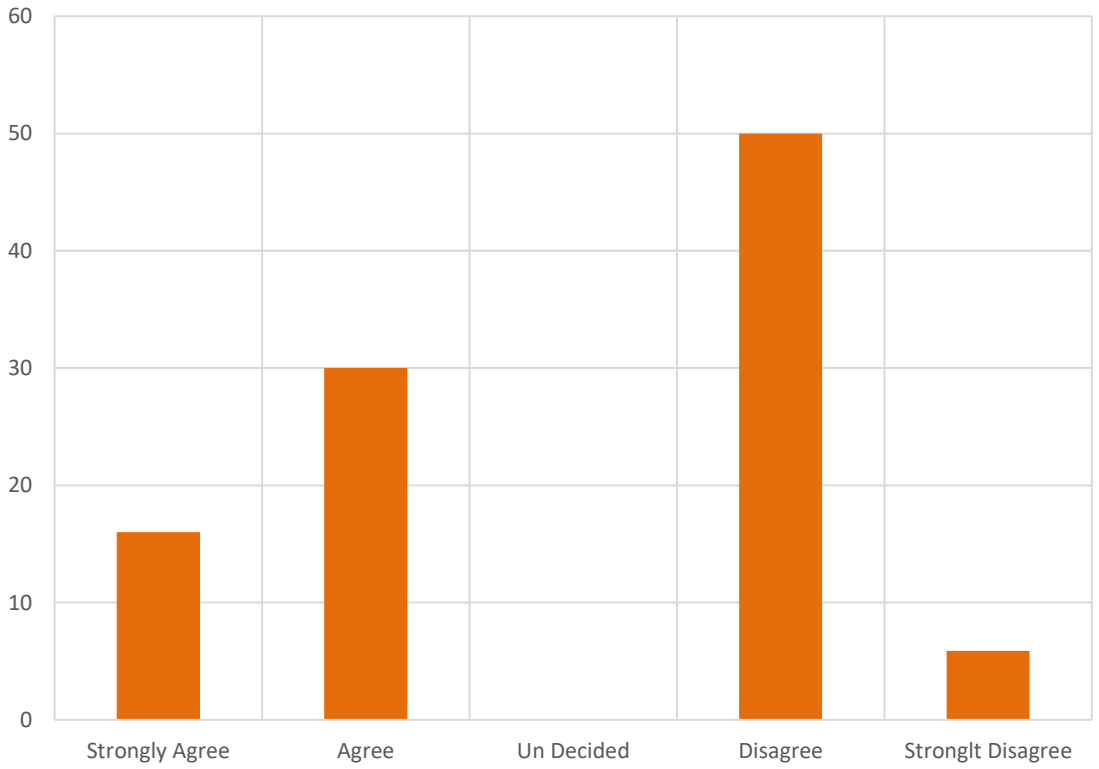


Fig 4.9: *Teachers regularly take students to laboratory for practicum.*

Fig 4.9 shows analysis of responses from 102 teachers. Out of 102 teachers 16% showed strongly agree response for statement and 30% showed agree response for statement. No one stand undecided. While 50% showed disagree response and 04% showed strongly disagreed response. The overall response of teachers for statement "Teachers regularly take students to laboratory for practicum." is disagreed.

Table 4.10

Teachers check practical note books of students on regular basis.

	SA	A	UD	D	SD	Total
Responses	16	62	-	21	3	102
Percentage	16	61	-	20	3	100

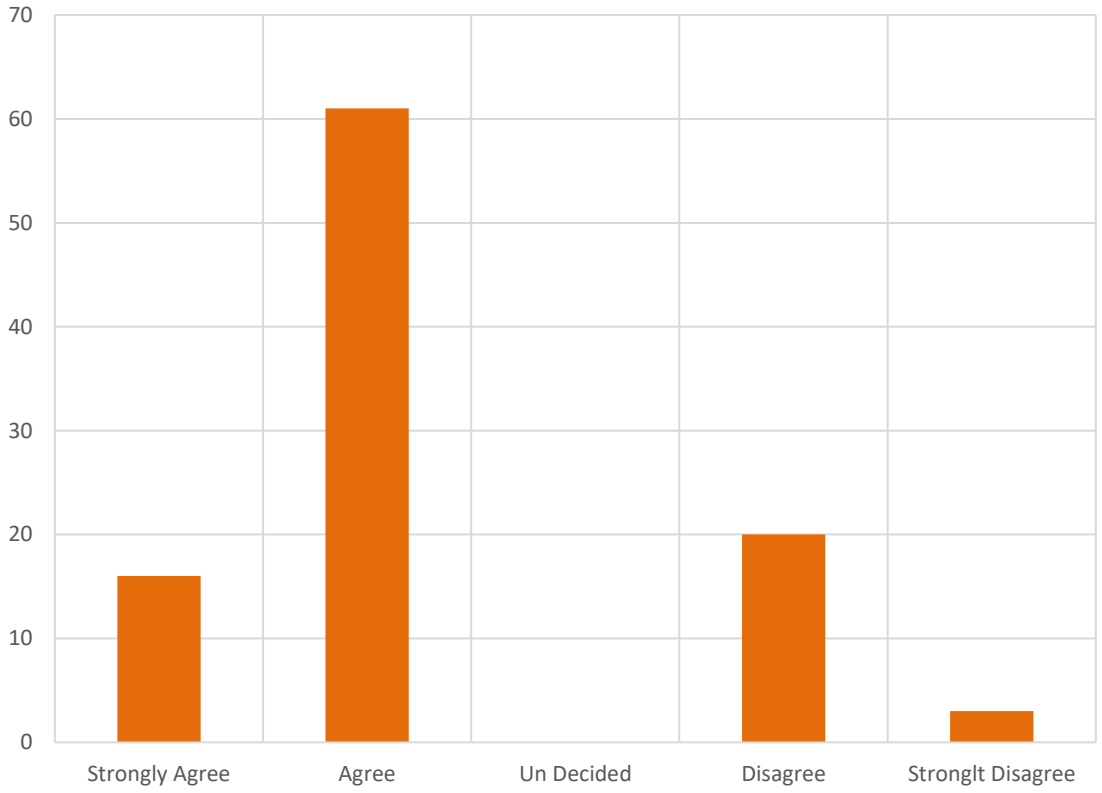


Fig 4.10: *Teachers check practical note books of students on regular basis.*

The analysis of data in Fig-4.10 revealed that out of 102 subjects 16% 'strongly agreed' to the statement, while 61 % 'agreed'. No subject response for 'un decided'. Those who 'disagreed 'were 20 %. The number of 'strong disagreed' response was3 %. The analysis revealed that the majority of 79.5% subjects indicated 'strongly agreed' opinion.

Table 4.11

Physics practicum has sufficient marks weightage in annual board examinations.

	SA	A	UD	D	SD	Total
Responses	10	28	06	50	08	102
Percentage	10	27	06	49	08	100

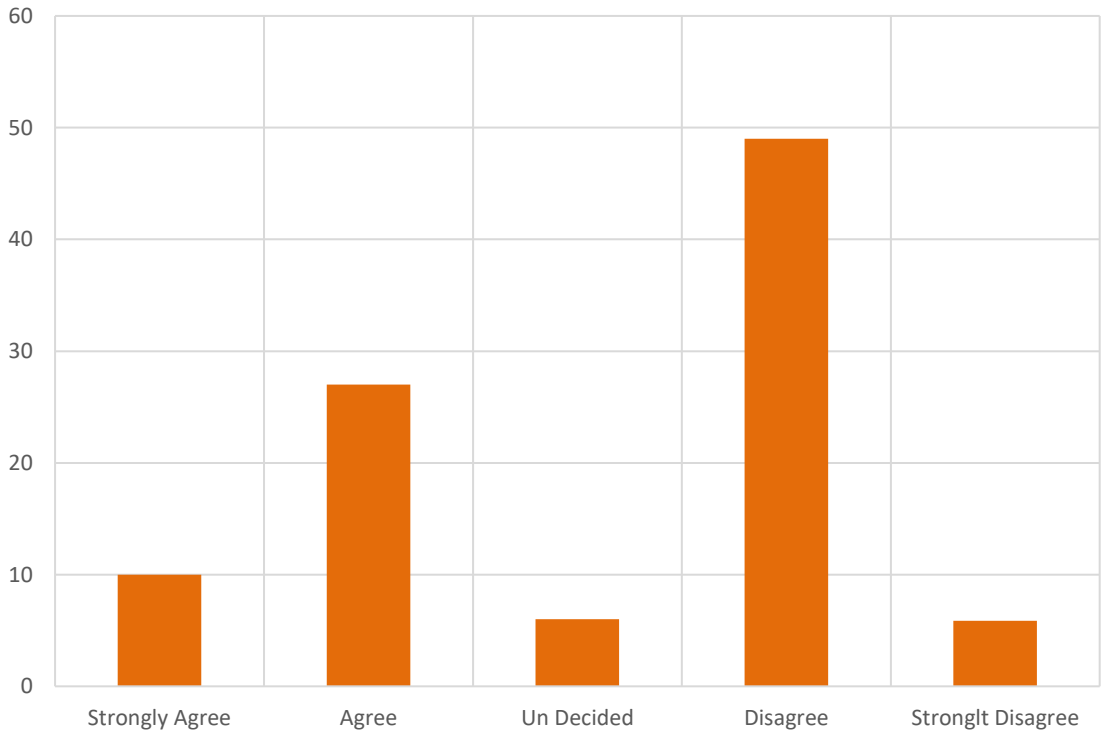


Fig 4.11: *Physics practicum has sufficient marks weightage in annual board examinations.*

Fig 4.11: shows analysis of responses from 102 teachers. Out of 102 teachers 10% showed strongly agree response for statement and 27% showed agree response for statement.06% teachers remained undecided. While 49% showed disagree response and 08% showed strongly disagreed response. The overall response of teachers for statement "Physics practicum has sufficient marks weightage in annual board examinations" is disagreed.

Table 4.12
Practicum examiners mostly asked viva vice questions related to memorization of facts.

	SA	A	UD	D	SD	Total
Responses	14	44	10	24	10	102
Percentage	14	43	10	23	10	100

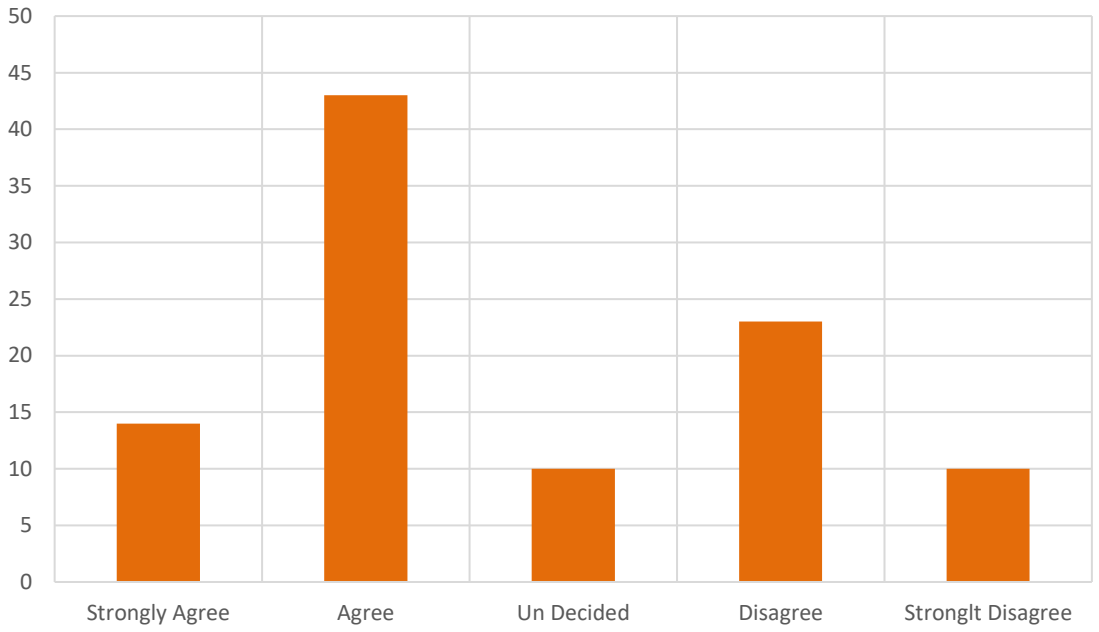


Fig 4.12: *Practicum examiners mostly asked viva vice questions related to memorization of facts.*

Fig 4.12 shows analysis of responses from 102 teachers. Out of 102 teachers 14% showed strongly agree response for statement and 43% showed agree response for statement. 10% stood undecided. While 23% showed disagree response and 10% showed strongly disagreed response. The overall response of teachers for statement "Practicum examiners mostly asked viva vice questions related to memorization of facts" is agreed.

Table 4.13

Teachers assess learning outcomes set in national curriculum of Physics, 2006 during practicum examination.

	SA	A	UD	D	SD	Total
Responses	10	30	10	40	12	102
Percentage	10	29	10	39	12	100

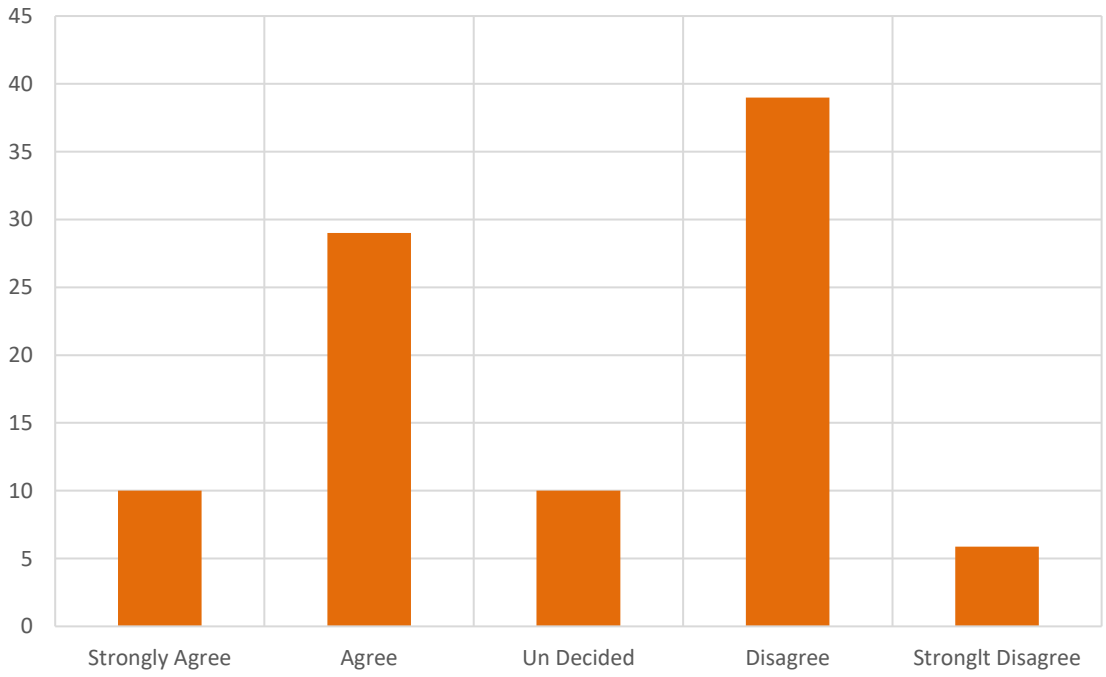


Fig 4.13: *Teachers assess learning outcomes set in national curriculum of Physics, 2006 during practicum examinations.*

Fig 4.13 shows analysis of responses from 102 teachers. Out of 102 teachers 10% showed strongly agree response for statement and 29% showed agree response for statement. 10% stood undecided. While 39% showed disagree response and 12% showed strongly disagreed response. The overall response of teachers for statement "Teachers assess learning outcomes set in national curriculum of Physics, 2006 during practicum examinations" is disagreed.

Table 4.14
Apparatus is provided to students for performing of experiment during practicum examinations

	SA	A	UD	D	SD	Total
Responses	15	52	-	25	10	102
Percentage	15	51	-	24	10	100

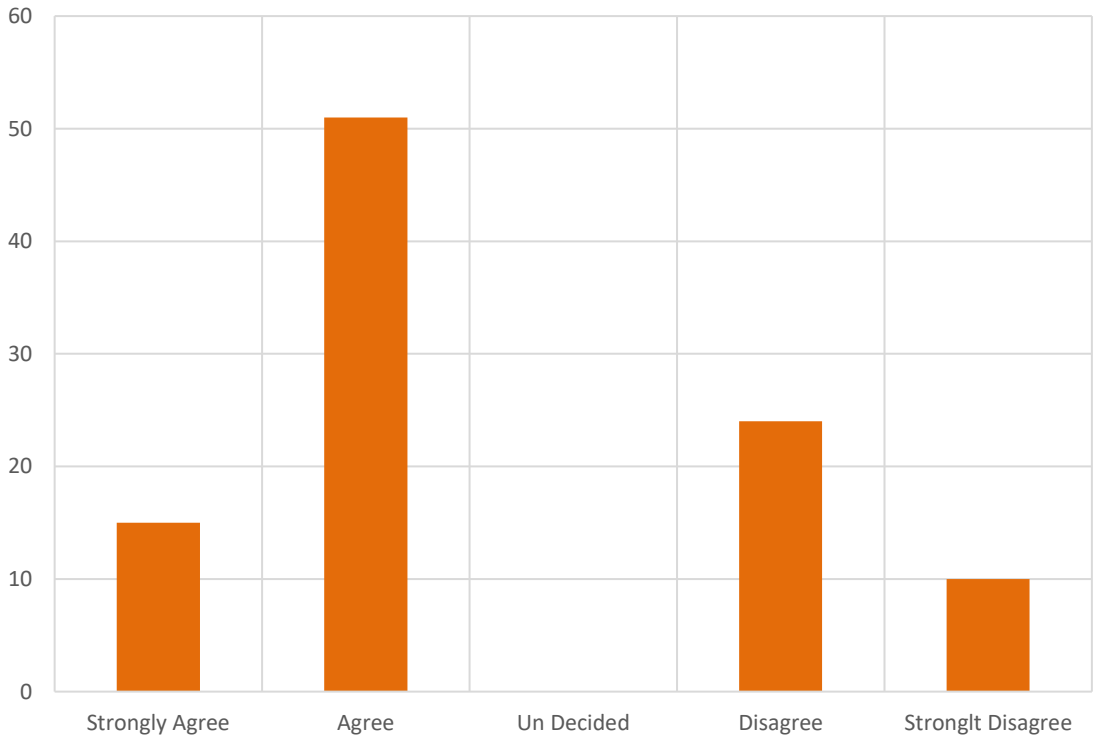


Fig 4.14: *Apparatus is provided to students for performing of experiment during practicum examinations*

Fig 4.14 shows analysis of responses from 102 teachers. Out of 102 teachers 15% showed strongly agree response for statement and 51% showed agree response for statement. No one stood undecided. While 24% showed disagree response and 10% showed strongly disagreed response. The overall response of teachers for statement "Apparatus is provided to students for performing of experiment during practicum examinations" is agreed.

Table 4.15

Students can successfully explain the data that they have computed during practicum.

	SA	A	UD	D	SD	Total
Responses	08	26	10	46	12	102
Percentage	08	25	10	45	12	100

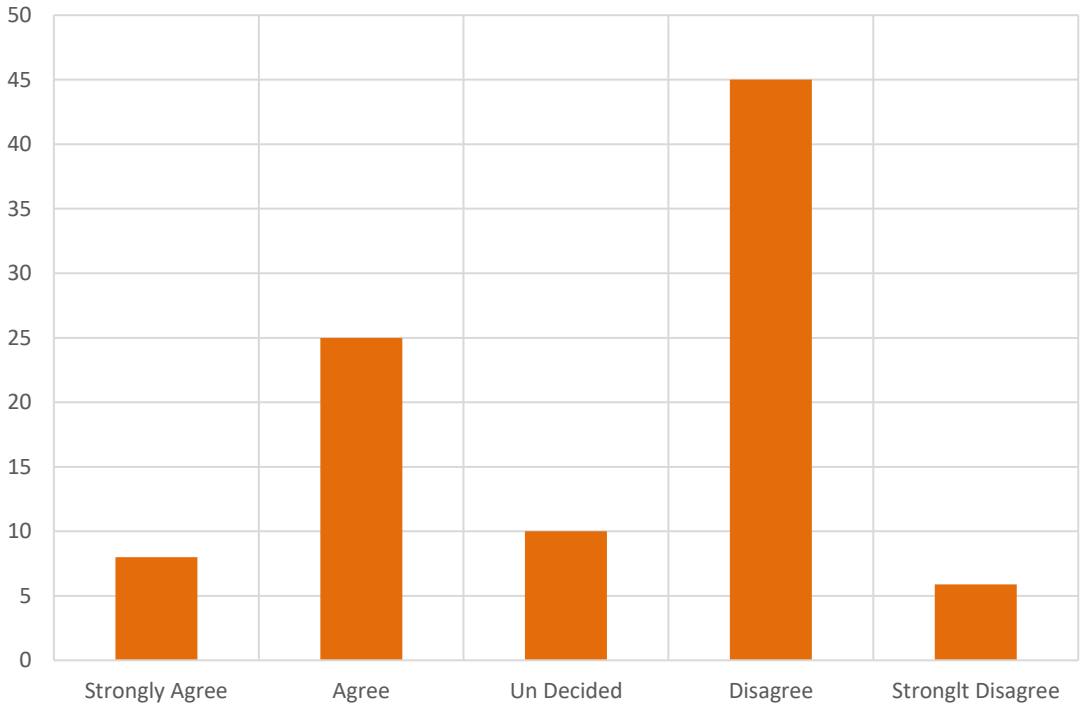


Fig 4.15: *Students can successfully explain the data that they have computed during practicum.*

Fig 4.15 shows analysis of responses from 102 teachers. Out of 102 teachers 08% showed strongly agree response for statement and 25% showed agree response for statement. 10% stood undecided. While 45% showed disagree response and 12% showed strongly disagreed response. The overall response of teachers for statement "Students can successfully explain the data that they have computed during practicum" is agreed.

Table 4.16

There are separate physics laboratories in schools

	SA	A	UD	D	SD	Total
Responses	16	53	05	21	07	102
Percentage	16	52	05	20	07	100

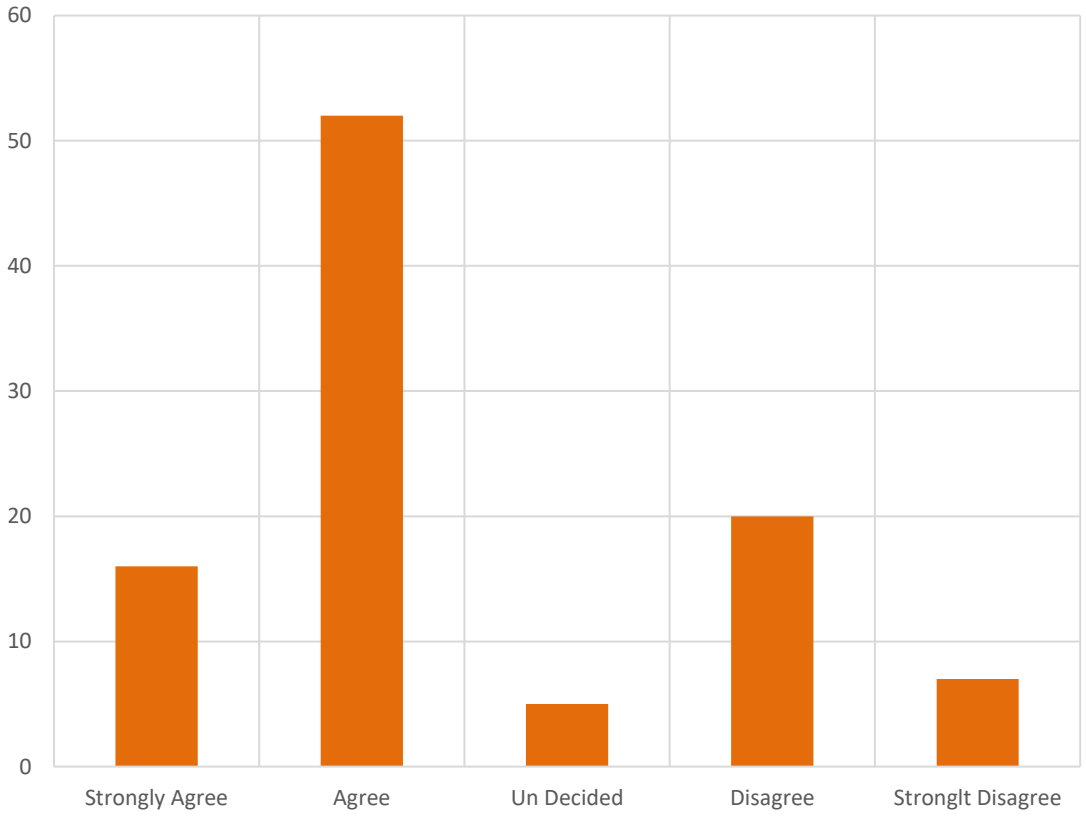


Fig 4.16: *There are separate physics laboratories in schools*

Fig 4.16 shows analysis of responses from 102 teachers. Out of 102 teachers 16% showed strongly agree response for statement and 52% showed agree response for statement. 05% stood undecided. While 20% showed disagree response and 07% showed strongly disagreed response. The overall response of teachers for statement "There are separate physics laboratories in schools" is agreed.

Table 4.17

Available apparatus in laboratories are in proper working conditions.

	SA	A	UD	D	SD	Total
Responses	14	47	10	25	06	102
Percentage	14	46	10	24	06	100

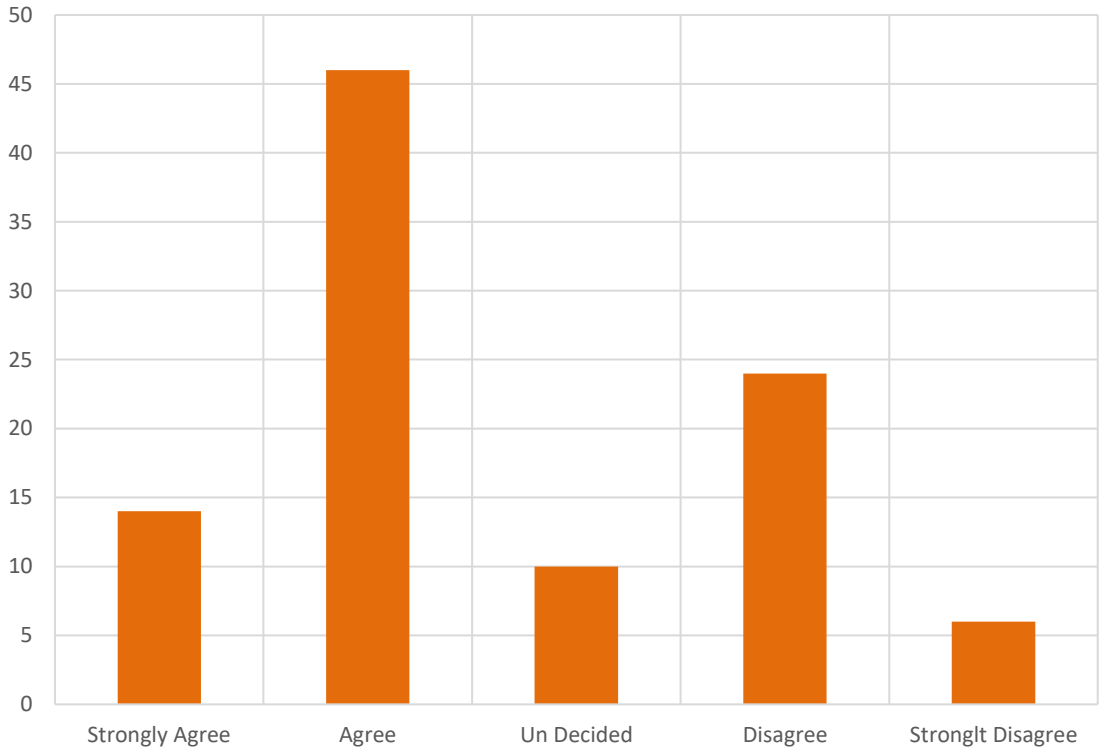


Fig: 4.17: *Available apparatus in laboratories are in proper working conditions.*

Fig 4.17 shows data analysis .Total respondents are 102. Out of 102 respondents 14% strongly agreed with statement and 46% agreed with statement. 10 teachers showed no response. While 24% respondents disagreed and 6% strongly disagreed. This analysis revealed that overall response for statement "Available apparatus in laboratories are in proper working conditions agreed".

Table 4.18

Class size for Physics practicum in secondary schools is suitable.

	SA	A	UD	D	SD	Total
Responses	04	16	-	62	20	102
Percentage	04	16	-	61	19	100

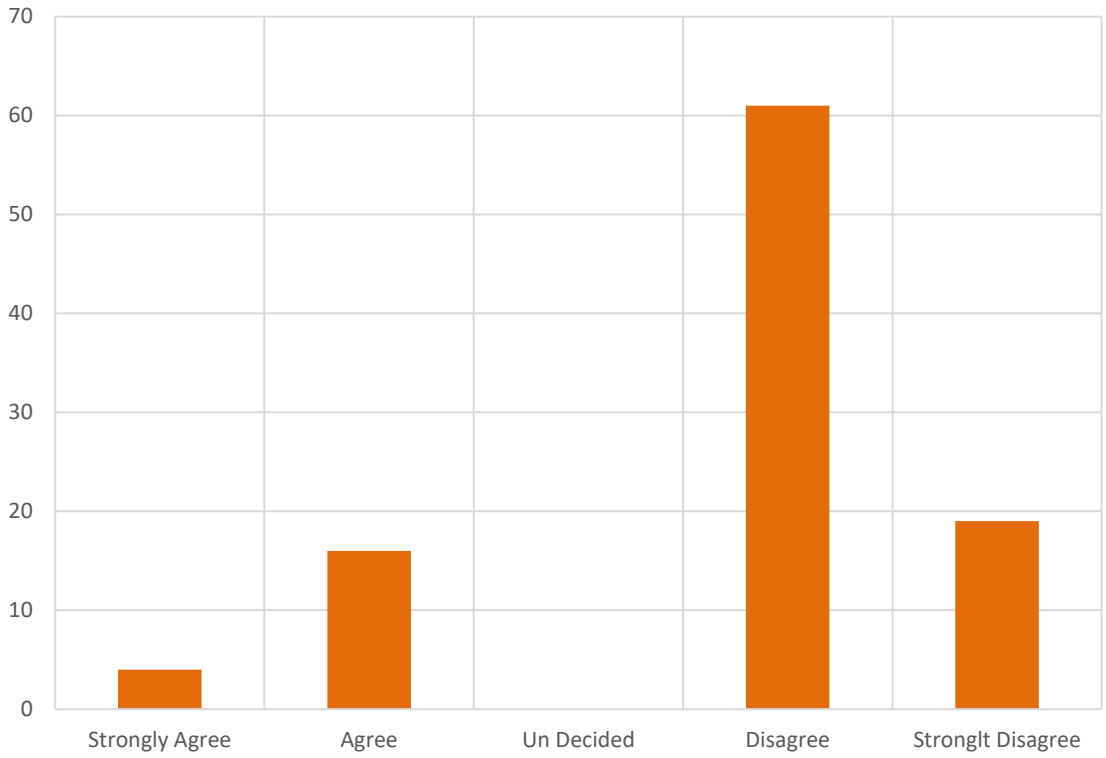


Fig 4.18: *Class size for Physics practicum in secondary schools is suitable.*

Fig 4.18 shows analysis of responses from 102 teachers. Out of 102 teachers 04% showed strongly agree response for statement and 16% showed agree response for statement. No respondents stood undecided. While 61% showed disagree response and 19% showed strongly disagreed response. The overall response of teachers for statement "Class size for Physics practicum in secondary schools is suitable.'' is disagreed.

Table 4.19

Time allocated from Physics practicum in time table is sufficient.

	SA	A	UD	D	SD	Total
Responses	05	24	05	55	13	102
Percentage	05	23	05	54	13	100

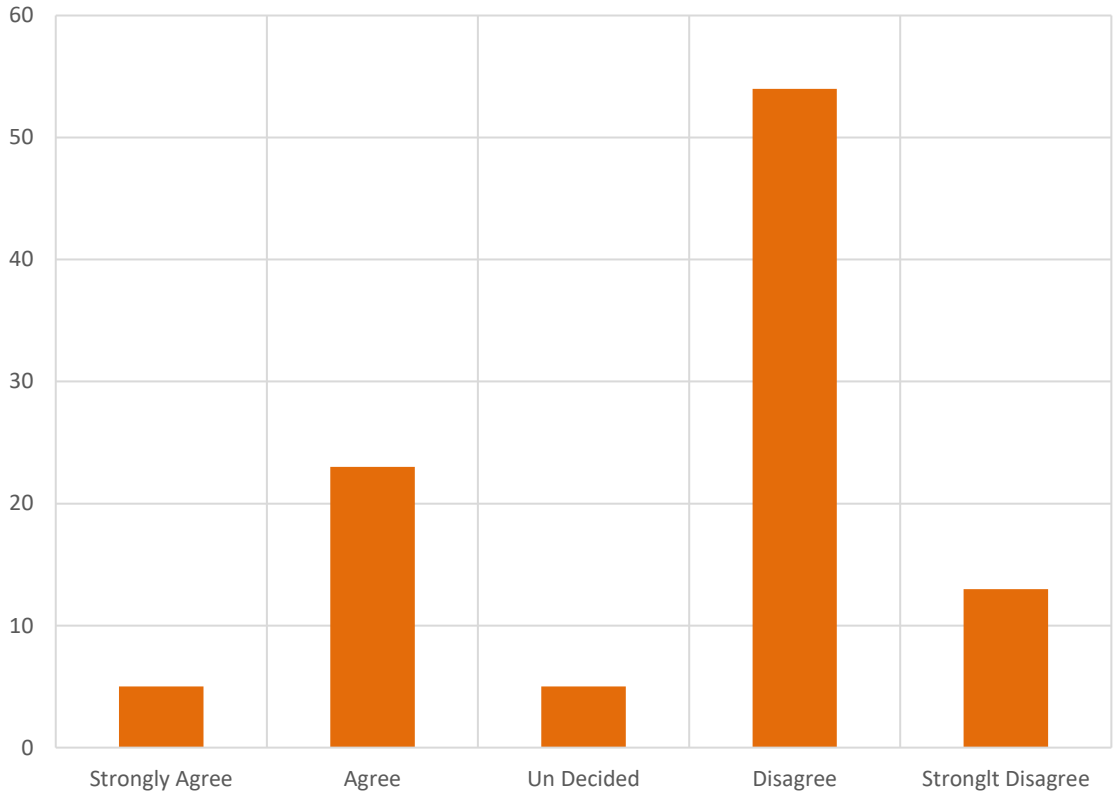


Fig 4.19: *Time allocated from Physics practicum in time table is sufficient.*

The analysis of data in Fig 4.19 revealed that out of 102 subjects 05% 'strongly agreed' to the statement, while 23% 'agreed'. 5% subjects response for 'un decided'. Those who 'disagreed' were 54%. The number of 'strong disagreed' response was 13%. The analysis revealed that the majority of 67% subjects indicated 'strongly disagreed' opinion.

Table 4.20

Teachers pre-service training emphasized on practicum.

	SA	A	UD	D	SD	Total
Responses	07	32	07	40	16	102
Percentage	07	31	07	39	16	100

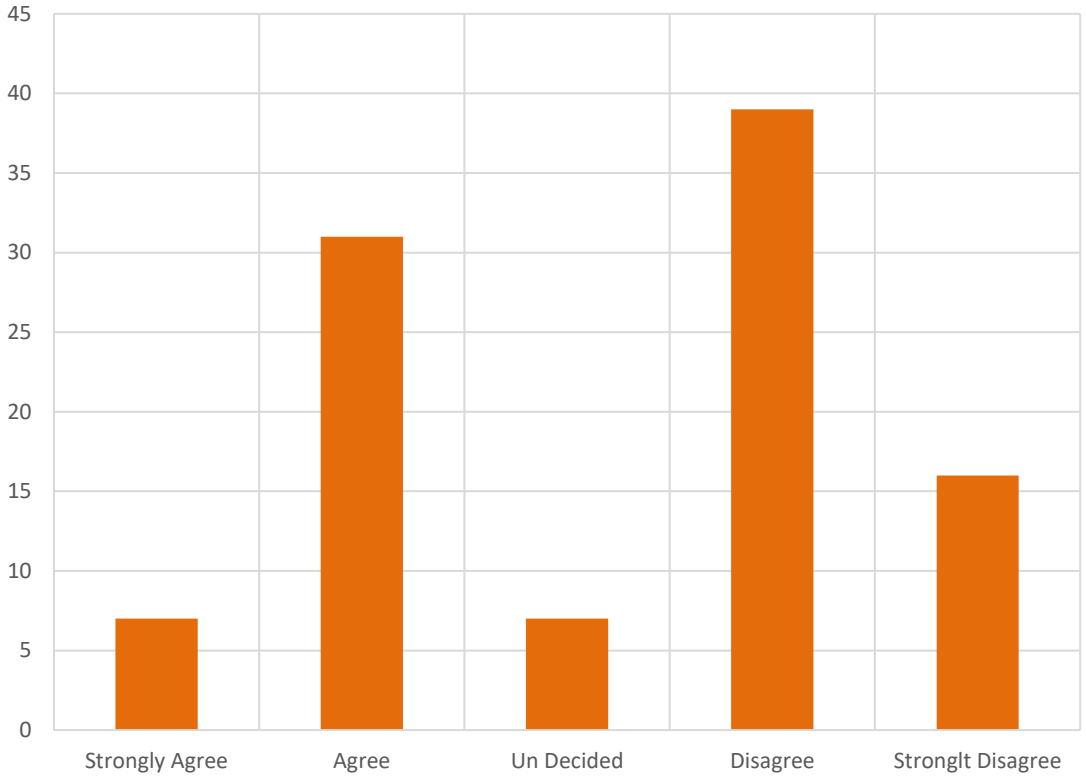


Fig 4.20: *Teachers pre-service training emphasized on practicum.*

The analysis of data in Fig 4.20 revealed that out of 102 subjects 07% 'strongly agreed' to the statement, while 31% 'agreed'. The responses of 'undecided' subjects were 07%. Those who 'disagreed' were 39% in number. The number of 'strong disagreed' response was 16%. The given statement received extensively 'disagreed' response from 55% subjects out of the total number of 102 subjects.

Table 4.21

Approaches are made to practical examiners for good Practicum marks.

	SA	A	UD	D	SD	Total
Responses	19	54	04	20	05	102
Percentage	19	53	04	19	05	100

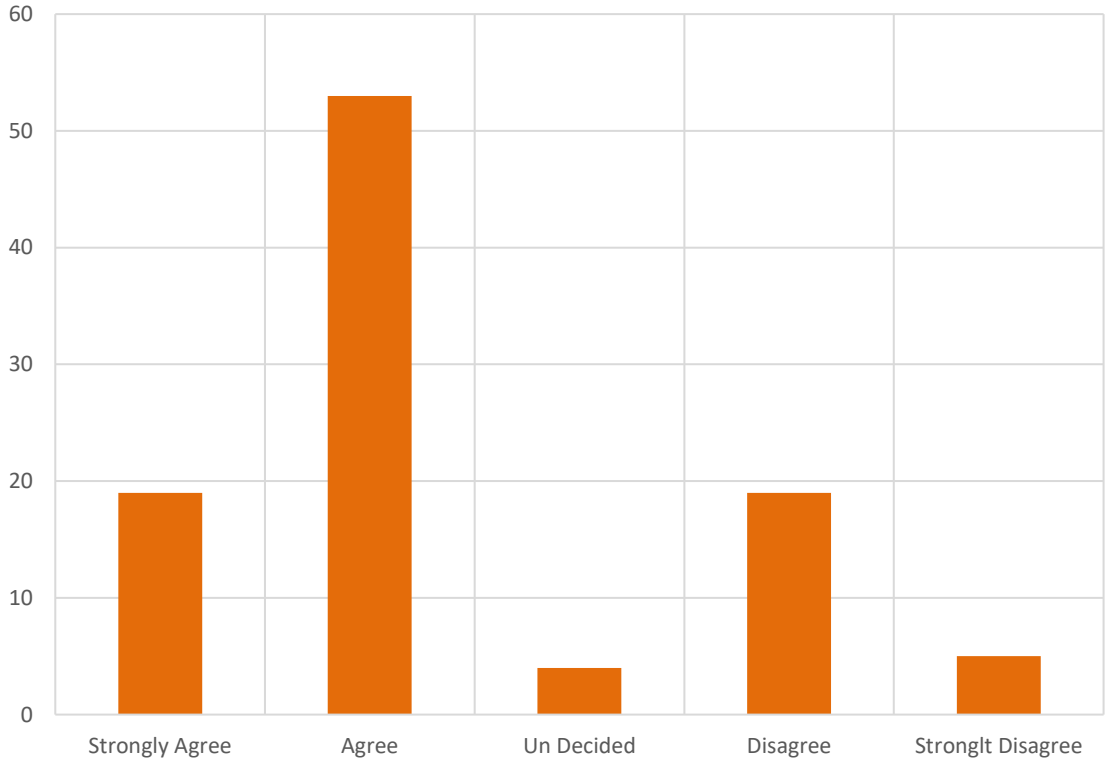


Fig 4.21*: Approaches are made to practical examiners for good practicum marks.*

Fig 4.21 shows analysis of responses from 102 teachers. Out of 102 teachers 19% showed strongly agree response for statement and 53% showed agree response for statement. 04 respondents stood undecided. While 19% showed disagree response and 05% showed strongly disagreed response. The overall response of teachers for statement “Approaches are made to practical examiners for good practicum marks’’ is agreed

Table 4.22

Teachers focus more on theory than practicum.

	SA	A	UD	D	SD	Total
Responses	17	56	-	22	07	102
Percentage	17	55	-	21	07	100

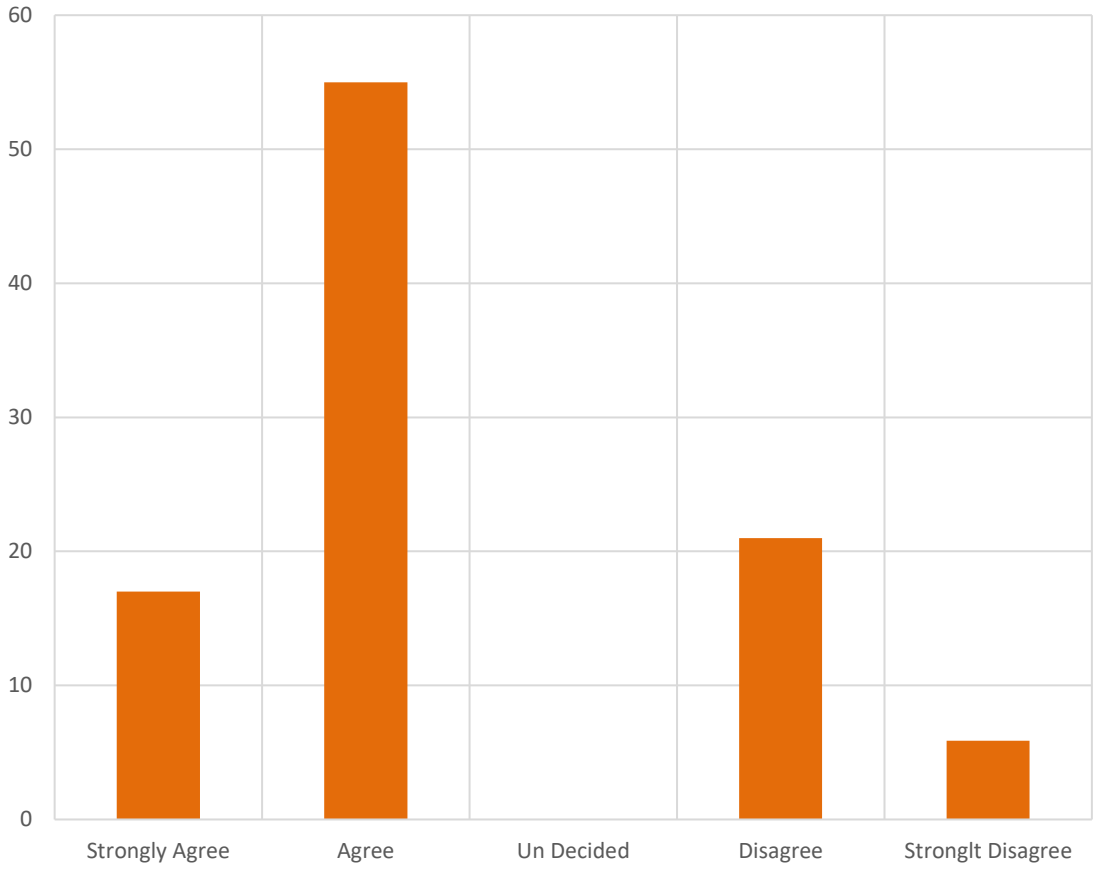


Fig 4.22*: Teachers focus more on theory than practicum.*

Fig 4.22 shows analysis of responses from 102 teachers. Out of 102 teachers 17% showed strongly agree response for statement and 55% showed agree response for statement. No respondents stood undecided. While 21% showed disagree response and 07% showed strongly disagreed response. The overall response of teachers for statement "Teachers focus more on theory than practicum'' is agreed.

Table 4.23

Students focus more on theory than practicum.

	SA	A	UD	D	SD	Total
Responses	15	50	07	24	06	102
Percentage	15	49	07	23	06	100

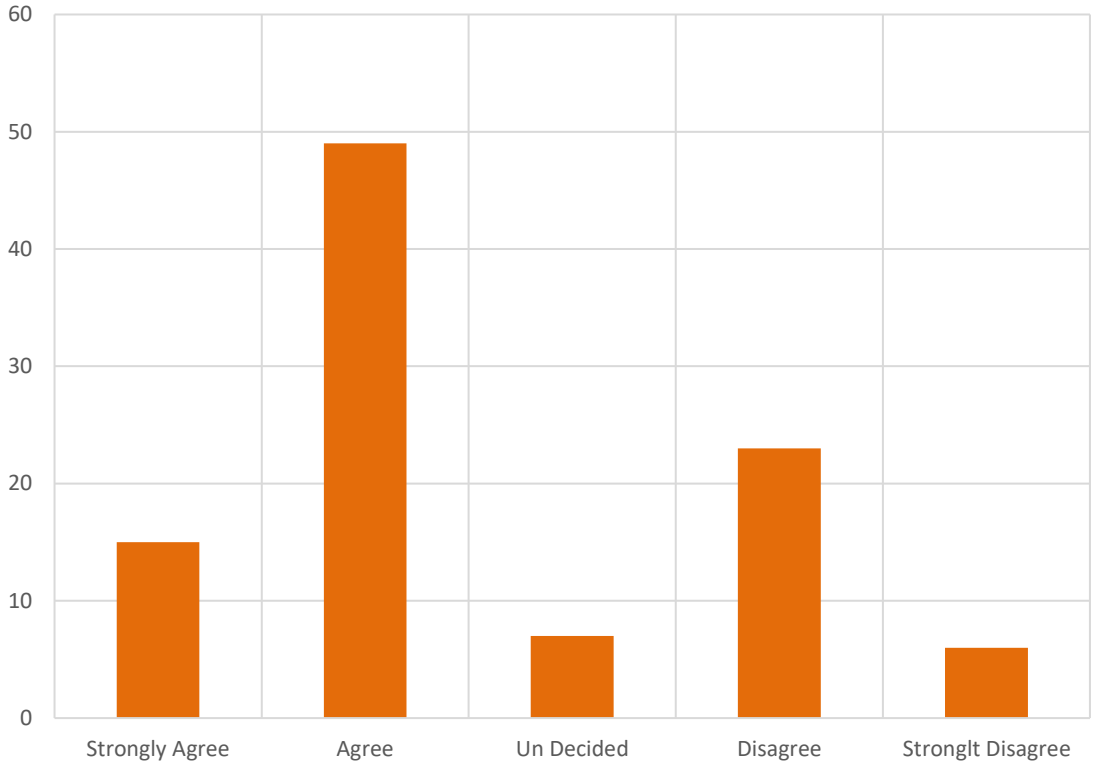


Fig 4.23: *Students focus more on theory than practicum.*

The analysis of data in Fig 4.23 revealed that out of 102 subjects 15% 'strongly agreed' to the statement, while 49% 'agreed'. The 'undecided' response was 07%. Those who 'disagreed' were 23% in number. The number of 'strong disagreed' response was 06%. The given statement received extensively 'agreed' response from 64% subjects of the total respondents.

Table 4.24

Practicum examiners conduct practicum examinations according to its true spirit.

	SA	A	UD	D	SD	Total
Responses	10	30	13	40	09	102
Percentage	10	29	13	39	09	100

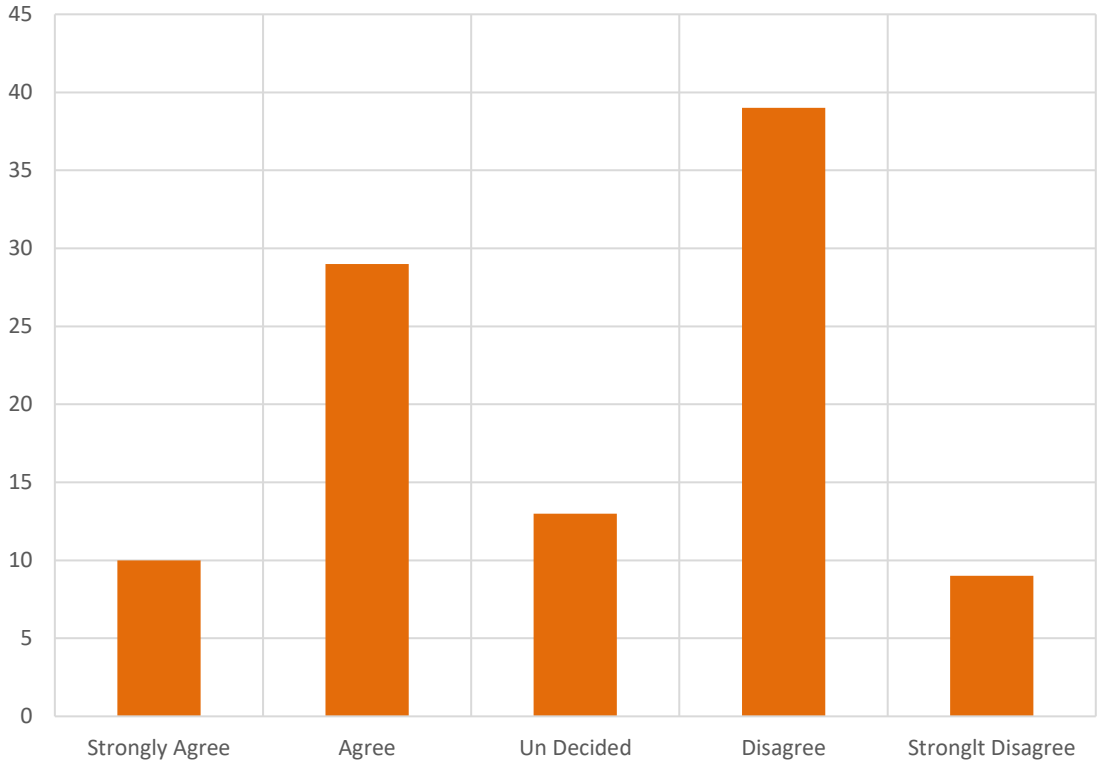


Fig 4. 24 Practicum *examiners conduct practicum examinations according to its true spirit.*

The analysis of data in Fig 4.24 showed that 10% ‘strongly agreed’ to the statement, while 29% ‘agreed’. The responses of ‘undecided’ subjects were 13%. Those who ‘disagreed’ were 39% while ‘strong disagreement’ was shown by 09% teachers. The given statement received extensively ‘disagreed’ response from 49 subjects out of the total number of 102 subjects.

Table 4.25

School principals encourage teachers for quality practicum.

	SA	A	UD	D	SD	Total
Responses	08	30	18	34	12	102
Percentage	08	29	18	33	12	100

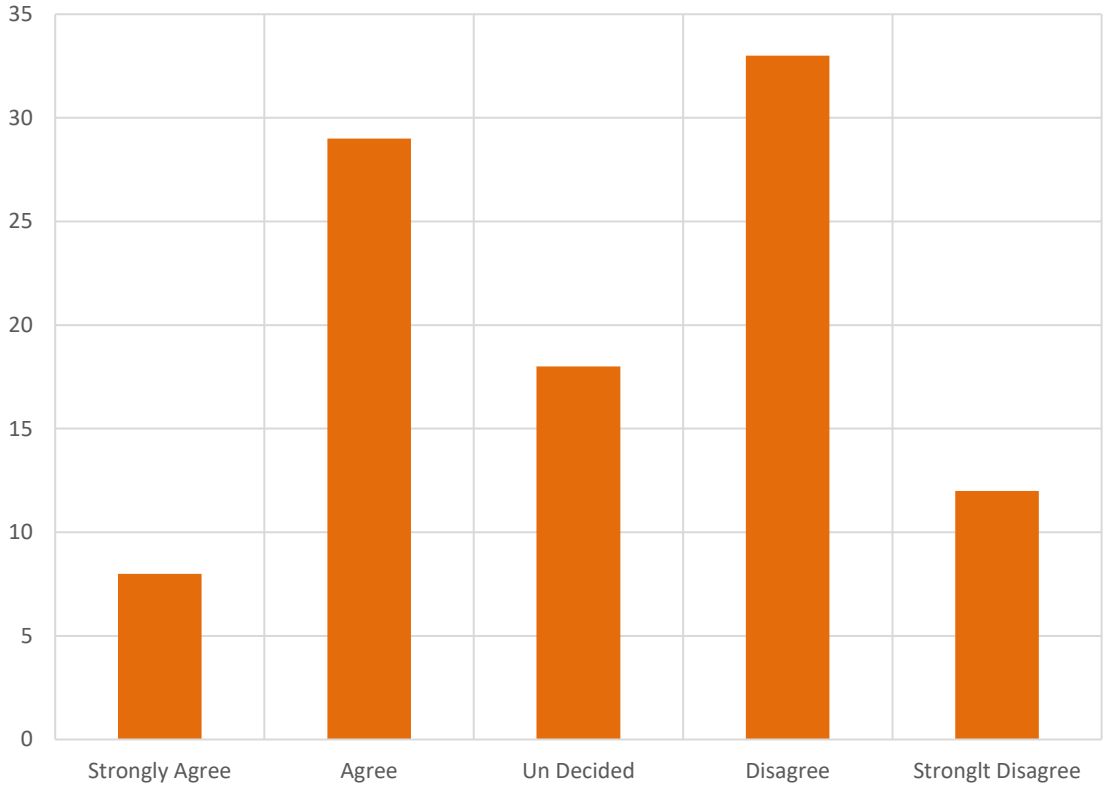


Fig 4.25: *School principals encourage teachers for quality practicum.*

The analysis of data in Fig 4.25 included the responses of 102 teachers, of those 08% subjects ‘strongly agreed’ to the statement, while 29% subjects ‘agreed’. The response of ‘undecided’ subject was 18%. The ‘disagreed’ response was 33% in number. The ‘strong disagreement’ was shown by 12%. The crux of the analysis is that the statement received significantly ‘disagreed’ response from majority of the respondents.

4.2 ANALYSIS OF OPEN-ENDED ITEMS IN QUESTIONNAIRE

There were two closed ended questions in the questionnaire. Data collected for these two questions is analyzed by thematic analysis. For thematic analysis first of all researcher transcript all the data. Then researcher read the data many times and find out common extract in the responses. Researcher used codes to highlight common ideas in the responses. After thorough review of these common ideas researcher generates themes. These themes are used to analyze the data.

First open ended question was about barriers in the implementation of the Physics practicum. We have a national framework for physics practicum in the form of National curriculum of physics, 2006. But there are some barriers in the implementation of this framework. It is very important to identify these barriers because without their identification and eradication Physics practicum cannot be implemented properly. So respondents were asked for barriers in the implementation of Physics practicum. Major Themes are generated from data for this question are given in following table

Table 4.26

Table of Themes.

S.No	Themes
1	Class Size
2	Teaching Methodologies for Physics Practicum
3	Assessment of Physics Practicum
4	Marks Weightage
5	Allocated Time for Practicum

Table 4.27

Barriers in the implementation of Physics practicum

S.No.	Responses	No. of respondents	Percentage
1	Large Class Size	92	90%
2	Inappropriate Teaching Methodologies	85	83%
3	Content of Book	81	79%
4	Poor Assessment Practices	77	75%
5	Less marks Weightage for practicum	70	68%
6	Less allocated time	70	68%

Above table presents data obtained for question "*Barriers in the implementation of Physics practicum"*

According to this data out of 105 respondents 92 declared large class size as a major barrier in implementation of Physics practicum, 82 believe that inappropriate teaching methodologies also contributes for poor implementation of Physics practicum, 81 says that poor implementation of practicum is also due to inappropriate content of book ,77 think that poor assessment practices also responsible for this, 70 say less marks weightage also generates momentum against implementation of practicum while 70 respondents believe that less allocated time is making implementation of practicum difficult.

According to thematic analysis of data give in Table 4.26 large class size,

inappropriate teaching methodologies, content of book and poor assessment are barriers for implementation of practicum. Respondents also believe that less marks weightage and less allocated time is also creating inertia against proper implementation of Physics practicum.

Second open-ended question was about suggestion for implementation of Physics practicum. We have a wonderful framework in the form of National Curriculum of Physics, 2006. But this framework is not implemented properly and affectively. This poor implementation is affecting Physics practicum at secondary level in Pakistan. As teachers teaching Physics practicum are most relevant people to Physics practicum so they are asked to give suggestion about proper implementation of Physics practicum according to the true spirit of National curriculum of Physics 2006. So respondents were asked to give their suggestions on this issue. Following themes are generated from the data for question *"Suggestions for implementation of Physics practicum"*

Table 4.28

Table of Themes.

S.No	**Themes**
1	Teacher's Training
2	Class Size
3	Content of Book
4	Marks Allocated for Practicum
5	Allocated Time for Practicum

Table 4.29

Suggestions for implementation of Physics practicum.

S.No	Responses	No. of respondents	Percentage
1	Teachers should be trained	90	88%
2	Appropriate teacher-student ratio	84	82%
3	Book should be modified	79	77%
4	Sufficient marks weightage for practicum	71	69%
5	Sufficient allocation of time	70	68%

Above table presents data obtained for question "*Suggestions for implementation of Physics practicum"*

According to this data out of 105 respondents 90 teachers suggested that teachers proper training can help in implementation of practicum, 84 believe that appropriate teacher-students ratio can reduce inertia against proper implementation of practicum, 79 suggested that by improving content of book implementation of practicum can be assured,71 think that sufficient marks weightage can contribute to proper implementation of practicum, 70 suggest that allocation of sufficient time for practicum can be supportive for implementation of practicum .

According to thematic analysis of data give in Table 4.27 teachers training, appropriate teacher-students ratio, proper content of book, sufficient marks weightage and sufficient allocation of time can help in proper implementation of Physics practicum.

CHAPTER 5

CONCLUSION, FINDINGS AND RECOMMENDATIONS

5.1 SUMMARY

Present era belongs to science and technology. Now a day science is playing very important role in almost all field of our life. All developed countries in the world have strong since education programs. Pakistan is a developing country. Pakistan needs a good science education program. There is a general perception that science education in Pakistan is facing many challenges. Due to importance of science education the researcher undertook the present study. The objective of study were

1. To highlight and review the National Curriculum of physics 2006(Grades IX-X) regarding set standards and benchmarks of Physics practicum.
2. To find out the facts and realities about physics practicum assessment at secondary level in Pakistan
3. To investigate the problems and challenges faced by teachers during preparation and assessment of Physics Practicum

This research was descriptive in nature. The population was comprised off all physics teachers teaching in federal government cant and garrison schools in Rawalpindi, Chaklala and Wha regions. By purposive sampling technique 125 teachers were selected as sample. The previous research studies, articles, documents and education policies were also studies. As science teachers are most relevant persons to physics practicum so it was decided to collect data from them through a questionnaire. The questionnaire was developed after careful review of related literature. The questionnaire was thoroughly examined by experts. Based on their advice some items were refined. For pilot testing twenty teachers were selected from

population. On the basis of pilot testing the language of some items was simplified because respondent feel difficulty in understanding them. The questionnaire was designed on five point likert scale. The option given in likert scale was strongly agree, agree, undecided, disagree and strongly disagree.

After pilot testing data was collected from the sample. For collection of data researcher personally visited the respondents. Respondents were thoroughly explained about topic of research and motives behind the research and were requested for their cooperation.

Findings of the research revealed that in Pakistan there is a wonderful policy for practicum of physics at secondary school level in the form of national curriculum of Physics, 2006. This policy is not properly implemented which affects the standard of our science education.

5.2 FINDINGS

The data collected through questionnaire was statistically analyzed and findings were classified into four broad categories for clarity.

(A) Awareness and Implementation of national curriculum of physics 2006

According to data obtained majority of teachers (68%) agreed that teachers know about Standard and bench marks set in national curriculum of Physics 2006 while 32% did not agreed with this statement. Only 32% respondents agreed with the statement that practicum at secondary schools in our country meets with these standards while 49% stand against it. Majority of teachers (64%) agreed that learning goals set in national curriculum are achievable and 24% responded against it. According to data majority of respondent (59%) declared that the content of Physics book is not appropriate while 30% claimed that it is appropriate. An important finding from collected is that 60% respondents agreed with the fact that practicum in our

secondary schools is not implemented according to spirit of national curriculum of Physics 2006 while 40% believed that practicum is implemented according to spirit of national curriculum of Physics, 2006.

(B) Preparation practices of practical work.

According to data obtained 49% of respondents disagreed with the fact that students are given access to apparatus while 41% think against it. Findings of data revealed that majority of respondents (44%) disagreed with the fact that students have freedom to perform practicum independently while a considerable number 39% believe against it. According to data obtained, 57% of respondents believe that teachers encourage students for asking questions while 34% did not believe on this fact. Most of teachers (77%) claimed that the practical note books are checked on regular basis while some (23%) did not claimed this.

(C) Assessment practices of practical work.

About 57% of teachers disagreed with the statement that practicum marks in annual examinations are sufficient while 37% stands with this marks weightage. Findings of data revealed that 57% of respondents agreed with the statement that mostly practical examiners asked viva vice question based on memorization of facts while 37% did not agreed with this. Another very important finding in this data is that majority of teachers (51 %) disagreed with the statement that teachers assess the learning outcomes set in national curriculum of Physics 2006 while 39% stands on other side. Majority of teachers (66%) agreed that apparatus is provided to students during practicum examination but on the other hand 34% did not agreed with this statement. 57% of respondents disagreed with the statement that students can exactly and successfully explained what they have computed while 33% believe that students can explain the data they have computed during practicum.

(D) Facilities for Practicum.

68% of respondents agreed with the statement that separate physics laboratories are available in schools while 27% did not believe so. 60% teachers convinced with the statement that apparatus available in laboratories are in proper working conditions while 30% respondents are not convinced. 80% of teachers are not satisfied with class size. Majority of teachers (67%) showed their dissatisfaction about allocated time for practicum while 28% showed their satisfaction on this statement. 55% of the teachers do not agreed with the statement that pre-service training emphasized on practicum while 38% agreed.

(E) Attitude of stakeholders toward Physics Practicum.

According to data collected 72% of respondents agreed with the statement that approaches are made to examiner for practicum marks while 24% show disagree response. 72% teachers support the facts that teachers give preference to theory while 28% did not support this fact. A majority of teachers (48%) agreed with statement that practicum examiners did not conduct practicum examination according to their true spirit while 39% show disagree response .According to 46% of respondents schools principal are not supportive for practicum.

5.3 Discussion

Assessment plays very important role in teaching and learning. Assessment is not only helps in student learning but it also gives an opportunity to teacher to review his own teaching for enhancing student learning. The standard of assessment in Pakistan is not good. Khan (2006) revealed in his studies that in Pakistan assessment do not judge real competencies of students Instead its supports reproduction of what a students have learnt in class Such assessment have very narrow scope .According to a study conducted by UNESCO (2007) assessment system in Pakistan inappropriate

and fail to measure the learning of students. This poor standard of assessment is affecting the standard of practicum at secondary level in.

Proper allocation of time for practicum is very necessary. Without proper allocation of time, practicum work cannot be properly implemented because teachers and students need enough time to carry out practical work Generally instead of proper allocation of time for practicum work a 30 to 40 minutes lessen period once in a week is used for practicum work which is not enough. Because out of this one period approximately all time is consumed in practicalities of the task and no time is left for discussion of ideas behind phenomenon. According to Millar and Abrahams (2009) during a practicum class teachers consumed most of the time in giving instructions, collecting equipment and manipulating data with very less or no time left for discussion with students for supporting the development of their knowledge.

According to scheme of studies for secondary classes the weightage for practicum marks for each science subject is just **15%,** which is very less. Higher order thinking demands more mind processing. Therefore, marks allocation for practicum work must be increased. Since theory contains 85% of total marks so it is natural that students will pay more attention on theory.

Large size of class is a major factor the effects implementation of practicum work at secondary school level. Researchers of USA, European countries, China and Japan believe that smaller classes provide better teaching and learning. In these countries efforts have been made to reduce class room size. It is very difficult for a teacher to maintain discipline in a big class. In laboratory due to large size of class students hardly get an opportunity for direct interaction with class teacher. Teacher cannot check the practicum note books of each and every student in large class. Nizamettin & Bekir (2014) have found negative correlation between teacher student

ratio and student's achievements. In Pakistan average students in a class are 60 to 70.It is very difficult for a science teacher to implement practicum work with true spirit in such a large class. Serious efforts are required to reduce class size because with such a large class size a teacher cannot implement practicum work in its true spirit.

Teacher's skills cannot be neglected for proper implementation of practicum work. Teacher's qualification, experience and pedagogic style significantly influence quality of practicum work. Carnoy, Khavenson & Jvanova (2015) argued in their research that teachers play a very key role in schools so they need to be properly skilled. According to Adeboyenga (2010) teachers have problems of how to teach in class. So they need to improve their teaching methodology. Sirait (2016) argued in his research that there is a positive relationship between teacher's quality and performance of students. Teachers have primary role in laboratory. Their authenticity means authenticity of practical work. According to Henshow (2013) proper implementation of practicum work is very helpful for students in solving their social problems.

Tebabal & Kahssay (2011) argued in their research that primary aim of education is to bring fundamental change in learner. In order to bring desirable changes in students a teacher uses some teaching method. Munyaradzi (2013) argued that a teaching method will be effective only if it is according needs of students and best suit specific objectives. According to Adunala (2011) poor academic performance by students is linked with in effective teaching method. According to the report of HEART (2012) inappropriate teaching methods is a factor for poor learning outcomes. The report further suggests without focusing on appropriateness of teaching method quality education con not be depart to students.

Another factor in the proper implementation of practicum work is attitude of

practicum examiners. Examiners normally do not make efforts for proper implementation of practicum work. They just enjoy the hospitality offered to them at the practicum l examiner centers. At the cast of this hospitality the award marks to the students. There practices should be discouraged. Last year federal board, Islamabad introduced two practicum examiners system in one center at intermediate level. This system proved very helpful in proper implementation of practicum work at higher secondary level.

5.4 Conclusion

Large class size is a great barrier for effective practicum work in Pakistan. Normally there are 60 to 70 students in a secondary level class. It is not possible for a teacher to handle such a big class. Most of the time is consumed in handling with students. With large class size students did not get time for discussion with teachers on their quires. Also teacher cannot check practicum note book of all students because of large class size.

Teachers are not skillful. They use inappropriate methodologies for teaching and assessing for Physics practicum. Mostly teachers use lecture method in Physics laboratories which is an inappropriate technique. Pre-service training for Physics teachers emphasize on theory and not on practicum work. This means our physics teachers are not properly trained. Teachers have also issues with assessment.

Teachers did not properly assess students during practicum examinations because they don’t know how to assess students. Normally teachers assess students in practicum examination on the basis of viva vice questions. During viva vice teachers mostly asked questions about memorization of facts. This means that grading of practicum examination is not true reflection of their performance in practicum examination.

Students are not allowed to use apparatus. Even those schools in which apparatus is

available students are not given access to apparatus because class teacher afraid the students will damage it and he have to answer to higher authorities. In some cases even school principal shows reluctance for regular use of physics laboratories because if fear that students may damage the apparatus.

Practicum work has been given very less marks weightage as compared to theory. Students got admission in college on the basis of their percentage in SSC annual board examinations. That's why students and even teachers focus more on theory than practicum. Because by attaining good marks in theory students can get good percentage in board examinations. Insufficient time is allocated for practicum work. In some cases even no time is allocated for practicum work in time table.

Insufficient allocation of time is also a barrier in implementation of physics practicum work. In many cases no time is allocated for practicum work in school time table. Teacher takes students in laboratories only few days before annual examination.

Practicum work is not implemented properly. Mostly students got marks in practicum by inappropriate means. Practicum examiners does not conduct practicum examinations according to their true spirit and enjoy hospitality at the examination centre.

5.5 Recommendations.

- Class size may be reduced. There may be suitable teacher student ratio. It is recommended that more secondary schools may be established so that burden on existing schools can be decreased. Government may also recruit more Physics teachers to ensure that there is no shortage of Physics teachers in secondary schools.
- Teachers may be trained for teaching of Physics practicum. They may be introduced with new methodologies for teaching of practicum. Government should introduced new teacher training programs which are designed for teaching of Physics practicum.

- Teachers may be equipped with new technologies like smart board, multimedia, Wi- Fi etc so that they can conduct practicum properly. Teachers may be trained for effective use of these technologies
- Teachers may be trained for assessment of practicum work. Teachers training programs may be modified according to needs and demand of time. Present training programs mostly focus on theory. These programs may be modified. FBISE is making some efforts in this regard but these efforts are not enough. All boards of secondary education and provincial education ministries may make collective efforts in this regard.
- Government may form committees comprises of expert science educators. These committees may frequently visit secondary schools and investigate that physics laboratories are properly used or not. Education department may take action on feedback of these committees.
- Less Weightage for practicum marks in also a barrier in proper implementation of practicum. .It may be increased. Because at present practicum work consists of 15 % of total marks .Students does not bother for practicum. Teachers also focuses more on theory because they believe that theory has greater marks weightage, by getting good marks in theory students can get good percentage in board examinations and this will bring a good name for them sand their institution. For this reason schools principals also focus more on theory and motivates teachers for theory and neglect practicum work.
- Sufficient time may be allocated for practicum. Because it is not possible for a teacher to take a class to Physics laboratory, perform practicum, check their performance, salve their quires and take class back to their class room.

- Last year FBISE Islamabad introduces two examiners system at higher secondary school level for practicum examinations. It is suggested that same procedure may be adopted for practicum examinations of secondary school level.

5.6 Suggestions.

- It is suggested that practicum of other science subjects i.e. Chemistry, Biology etc may also be analyzed.
- Our science education programs at primary and secondary level must be investigated.
- Teachers training programs for science teachers may be analyzed.
- Secondary schools examination system may be analyzed.
- Comparative studied about practicum at secondary schools in Pakistan and develop countries like U.S.A, America etc may be conducted.
- It may be investigated that practicum is developing higher order thinking in students or not.

5.7 Limitations

The researcher was also interested in collecting data from students but due to restriction of time and resources he cannot do so. The population of research was limited to F.G cant/garrison institutes this research may expand to all public and private schools of Punjab .As this research was carried out during the pandemic of Covid-19 during which practicum were not conducted so data was collected on the basis of past experiences of respondents.

REFERENCES

Abrahams, I. & Millar, R., (2008) Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching and learning method in school science, International Journal of Science Education, 30:14,1945-1969, International Journal of Science Education, 30 (14): 1945-1969.

Adunola, O. (2011),"The Impact of Teachers' Teaching Methods on the Academic Performance of Primary School Pupils in Ijebu-Ode Local cut Area of Ogun State," Ego Booster Books, Ogun State, Nigeria.

Akbar, R. A. (2012). Mind the fact: Teaching science without practical as body without soul. *Journal of Elementary Education*, *22*(1), 1-8.

Alam, M. T., & Farid, S. (2011). Factors affecting teachers motivation. *International journal of Business and social science*, *2*(1), 298-304.

Alsop, S. & Watts, M. (2003). Science education and affect. International Journal of Science Education, 25(9), 1043-1047.

Awan, M. N. (2015). Physical Conditions of Science Laboratories and Problems Faced by Science Teachers in Conducting Practicals in Punjab. *Bulletin of Education and Research*, *37*(1), 47-54.

Abrahams, L. & Millar, R. (2008). Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching method in science. *International Journal of Science Education. 30(14): 1945-1969*.

Adedayo, J. (2015). Analysis of factors influencing students' attitudes towards practical aspect of secondary school physics in Ekiti state. International Journal of Multidisciplinary Research and Development. 2: 417-421

Azim, S., & Khan, M. (2012). Authentic assessment: An instructional tool to enhance students learning. *Academic Research International*, *2*(3), 314.

Blatchford, P., & Lai, K. C. (2012). Class size: arguments and evidence. In B. McGraw, E. Baker, & P. P. Peterson (Eds.), *International encyclopedia of education* (3rd ed.). Oxford, UK: Elsevier.

Blatchford, P. (2003). *The class size debate: Is small better?* Maidenhead: Open University Press.

Carnoy, M., Khavenson, T., & Ivanova, A. (2015). Using TIMSS and PISA results to inform educational policy: a study of Russia and its neighbours. Compare: A

Journal of Comparative and International Education, 45(2), 248-271.

Chala, A. A. (2019). Practice and Challenges Facing Practical Work Implementation in Natural Science Subjects at Secondary Schools. *Practice*, *10*(31).

Chiappetta, E. L., & Koballa Jr., T. R. (2006).*Science Instruction in the Middle and Secondary Schools*. NJ: Pearson/Merrill Prentice Hall.

Cassidy, S and Eachus, P., (2000). Learning Style, Academic Belief Systems, Self-report Student Proficiency and Academic Achievement in Higher Education. *Educational Psychology*.Vol. 20, Issue. 3.

Carlson, A. (2000). Achieving Educational Quality: What Schools Teachers Learning from Chile's P900 Primary Schools. Restructuring and Competitiveness Net work. Division of Production, productivity and Management. Santiago, Chile.

Crouch, L., & Korda, M. (2009). Improvements in Reading Skills in Kenya: An Experiment in the Malindi District. Research Triangle Park, NC: RTI International.Retrievedfromhttp://ddpext.worldbank.org/EdStats/KENdprep09.pdf

Doran, R., Lawrenz, F. & Helgeson, S. (1994). 'Research on Assessment in Science', in D. Gabel (ed.), Handbook of Research on Science Teaching and Learning, Macmillan, NY, 388—44

Faize, F. A. (2011). *Problems and prospects of science education at secondary level in Pakistan* (Doctoral dissertation, International Islamic University, Islamabad).

Forehand, M. (2010). Bloom's taxonomy. *Emerging perspectives on learning, teaching, and technology*, *41*(4), 47-56.

Ganyaupfu, E. M. (2013). Teaching methods and students' academic performance. *International Journal of Humanities and Social Science Invention*, *2*(9), 29-35.

Gillham, B. (2008). *Developing a questionnaire*. A&C Black.

Giddings, G. and B.J. Fraser, 1988. Assessment of students' learning in science education. In I. Layton (Ed.), Innovations in science and technology 12. education. Paris: UNESCO Publication.

George R., Kaplan M. D. (1998). A structural model of parent and Teacher influences on students' attitudes of eight grades. Evidence from NELS. 88 Science, 82(1): 93-109.

Gonzalez-Pienda, J.A, Nunez, J.C., Gonzalez-Pumariega, S., Alvarez, L., Roces, C. &

Garcia, M. (2002). A Structural Equation Model of Parental Involvement, Motivational and Aptitudinal Characteristics, and Academic Achievement. *The Journal of Experimental Education*, 70(3), pp. 257-287

Henshaw .H. N. (2013). Chemistry Education, a tool for social Reconstruction and Transformation in Nigeria Problems and Prospects. Niger Delta Journal of Education, 2, 171-178.

.Hussein, F., & Reid, N. (2009). Working memory and difficulties in school chemistry. *Research in Science & Technological Education*, *27*(2), 161-185.

Hussain, T, Hashmi, A., & Perveen, Z. (2020). Attitude towards Teaching Profession in Pakistan: A Case of Public Sector Secondary School Teachers. *Pakistan Social Sciences Review*, *4*(2), 483-491.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, *71*(256),33–40.

Hijazi, Syed Tahir and Naqvi, S.M.M. Raza (2006), Factors Affecting Students' Performance: A Case of Private Colleges.*Bangladesh e-Journal of Sociology*.Volume 3.Number 1. January 2006.

Jenkins, E. (2002). The schooling of laboratory science. In: J. Wellington (Ed.), *Practical work in school science: which way now?* London: Routledge, (93-108)

Johnson, L. (2011). Does class size really matter? *District Administration*, *47*(9), 104-105.

Kapting'ei, P. and Kimeli, D. (2014). Challenges Facing Laboratory Practical Approach In Physics InstructionIn Kenyan District Secondary Schools. International Journal Of Advancements In Research & Technology. 3:,2278-7763

KHAN, S. (2006) *An evaluation of the exercises provided in the English compulsory textbook for class X,* [Unpublished MA dissertation] Faculty of English Linguistics, University of Karachi.

Khan, P., & Iqbal, M. (2012). Overcrowded classroom: A serious problem for teachers. *University of Science and Information Technology*, *49*, 10162-10165.

Khan, R.M.; Khan, M. A &Zubairi, N. (1999). Parental Involvement and reading Attainment: A Study of 4th Grade Pakistani Children, *Journal Pendidikan*,20, pp. 83-94, Fakulti Pedidikan University, Malaya,

Kızıltepe, Z. (2008). Motivation and demotivation of university teachers. *Teachers*

and Teaching, 14, 515–530.

Klassen, A. C., Creswell, J., Clark, V. L. P., Smith, K. C., & Meissner, H. I. (2012). Best practices in mixed methods for quality of life research. *Quality of life Research*, *21*(3), 377-380.

Mokotedi, R.T. (2013). Beginning Primary School Teachers' Perspectives on the Role of Subject Specialization in Botswana Colleges of Education. International Journal of Scientific Research in Education 6(1): 88-99.

. Muleta, T., & Seid, M. (2016). Factors affecting implementation of practical activities in science education in some selected secondary and preparatory schools of Afar region. *African Journal of Chemical Education*, *6*(2), 123-142.

Lunetta, V N, Hofstein, A and Clough, M., (2007). Teaching and learning in the school science laboratory. An analysis of research, theory, and practice. In Handbook of research on science.

Millar, R. H. (2004). The role of practical work in the teaching and learning of science, High School Science Laboratories: Role and Vision. National Academy of Science, Washington, DC.

Millar, R., & Abrahams, I. (2008). Does Practical Work Really Work? A study of the effectiveness of practical work. *International Journal of Science Education*, *30,* 1945-1969.

Mulela, M. M. (2015). *Effects of availability and use of laboratories on students performance in science subjects in community secondary schools* (Doctoral dissertation, The Open University of Tanzania).

Monk, M. & Osborne, J. (2000). *Good practice in Science teaching: What research has to say.* Buckingham-Pbiladelphia: Öpen University Press.

National Research Council. 2000. *How People Learn: Brain, Mind, Experience, and School*: Expanded Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/9853.

National science teacher association (NSTA) 2006. NSTA position statement; Professional development in science instruction.

Naar, A.H.(2016, March 4) Science education in schools, The Dawn https://www.dawn.com/news/1243391

Okpala, C.O., Okpala, A.O, & Smith, F.E. (2001). Parental Involvement, Instructional Expenditures, Family Socioeconomic Attributes, and Student Achievement. *The Journal of Educational Research,* 95(2), pp. 110-115

Oliver, P. (2010). *The student's guide to research ethics*. McGraw-Hill Education (UK).

Onderi, H, Kiplangat, R.K. and Awino, J (2014) Factors Contributing to Poor Academic Performance in Kenya Certificate Of Secondary Education in Public Secondary Schools In Kericho Sub – County ,

Oni, J.O., (1995). Educational Resource: An Introduction; Abeokuta, Gbemi Sodipo Press Ltd.

Olayiwola, O.M.,Salawu, I.F. Oyenuga, J. O. Oyekunle, A. Ayansola, J . T. Olajide and S. A. Agboluaje. (2011). *On Statistical Analysis of Impact of Socio Economic Factors on Students' Academic Performance.* http://www.arpapress.com/Volumes/Vol8Issue3 /IJRRAS_8_3_15.pdf[Accessed 15 October 2014].

Osborne, J. (2000). Keynote speech. In M. Poisson (Ed.), *Science education for contemporary society:Problems, issues and dilemmas* (pp. 8-12). Beijing, China:Retrieved from ERIC database. (ED 452055)

REHMANI, A. (2003) Impact of Public Examination System on Teaching and Learning in Pakistan *International Biannual Newsletter ANTRIEP,* 8 (2) Pp.3-7.

Roediger III, H. L., & Karpicke, J. D. (2006). The power of testing memory: Basic research and implications for educational practice. *Perspectives on psychological science, 1*(3), 181-210.

Siddique, H. (2011, April 5). Practical exams on sale. *Pakistan today*, 15 https://archive.pakistantoday.com.pk/

Sirait, S. (2016). Does teacher quality affect student achievement? An empirical study in Indonesia. *Journal of Education and Practice, 7*(27).

Singh, G. (2014). Review of Research on School Science Laboratory Work With Special Emphasis on Physics Education.

Shulman, L.S & Tamir, P. (1973). Research on teaching in the natural science. In R.M.V. (Ed).Second hand book of Research on Teaching Chicago: Rand Mc Nully.

Shah, J. and Inamullah, M. (2012). The Impact of Overcrowded Classroom on the Academic performance of the Students at Secondary Level. International Journal of Researc in Commerce, Economics and Management. Volume No.2, Issue No.6 (June) ISSN 2231-4245, India

SHAH, D. & AFZAAL, M. (2004)The examination Board as Educational Change Agent: The Influence of Question choice on selective study. Paper presented at *30th annual IAEA Conference*. Philadelphia, United States of America.

Tebabal, A. & Kahssay, G. (2011), "The effects of student-centered approach in improving students' graphical interpretation skills and conceptual understanding of kinematical motion," *Lat. Am. J. Phy. Edu*, 5(2): 374-381.

Tugel, B. J. (1994). Pollution, pH and problem solving. *The Science Teacher*, 21-25.

UNESCO (United Nation Educational Scientific and Cultural Organization) (2007) *The Education System in Pakistan: Assessment of the National Education Census,* Islamabad: UNESCO.

Van Voorhis, F.L. (2003). Interactive Homework in Middle School: Effects on Family Involvement and Science Achievement. *The Journal of Educational Research,*96 (6),pp. 323-338

Vince, J. (2017). Trigonometry. In *Mathematics for Computer Graphics* (pp. 51-63). Springer, London.

Viljaranta, J., Tolvanen, A., Aunola, K., & Nurmi, J. E. (2014). The developmental dynamics between interest, self-concept of ability, and academic performance. *Scandinavian Journal of Educational Research*, *58*(6), 734-756.

Woolnough, B. (1991). *Practical Science.* Milton Keynes- Philadelphia: Öpen University Press.

Yung, B. H. W. (2001). Three views of fairness in a school-based assessment scheme of practical work in biology. International Journal of Science Education, 23: 985–1005.

APPENDIX A

List of Institutions (High School(I-X))

1	Wah Region	FG Public School No.6 (Girls) Wah Cantt	051-9314328 -	fgpsno6girlswah@gmail.com
2	Wah Region	FG Public School No.2 (Girls) Wah Cantt	0514903371	2pgs1953@gmail.com
3	Wah Region	FG Public School No.3 (Girls) Wah Cantt	0514902259	fg.ghs3.1st.wahcantt@gmail.com
4	Wah Region	FG Public School No.4 (Girls) Wah Cantt	0514531920 NIL	fg.ghs4.1st.wah@gmail.com
5	Wah Region	FG Public School No.7 (Girls) Wah Cantt	051-4511863 24429(P.O.F)	fgps07wahcantt@gmail.com
6	Wah Region	FG Public School No.4 (Boys) Wah Cantt	0514902715	fg.bhs9.1st.wah@gmail.com
7	Wah Region	FG Public School No.5 (Boys) Wah Cantt	0514909373	bhs11wah@yahoo.com
8	Wah Region	FG Public School PAC Kamra	0579317213 05190996448	phspac001@gmail.com
9	Wah Region	FG Public School AMF Kamra	051-90995480 057-9315118	fgpsamfk@gmail.com
10	Wah Region	FG Public School KARF Kamra	0579317248 051-9099-6385	fggpsskamra@gmail.com
11	Wah Region	FG Public School Taxila	0514908118	fgphstax@gmail.com

12	Wah Region	FG Public School No.1 (Girls) Taxila	05149315333 Nil	fgtaxila@gmail.com
13	Wah Region	FG Public School Havelian	0992407334 0	Farhad_sheereen@yahoo.com
14	Wah Region	FG Public School No.1 (Boys) Havelian	0992 407086	fgpublicschool1boyshvn@gmail.com
15	Wah Region	FG Public School (Boys) Sanjwal	057916627794	fgpsbsanjwal@gmail.com
16	Wah Region	FG Public School (Girls) Sanjwal	057-916627793 057-9316317-2	pgssanjwal@gmail.com
17	Wah Region	FG Public School No.1 (Girls) Wah Cantt	0519314317	fgps01@gmail.com
18	Wah Region	FG Public School No.5 (Girls) Wah Cantt	0514902330 0519310021	fgghsno5wah@gmail.com
19	Wah Region	FG Public School No.2 (Boys) Wah Cantt	0514511725 22406	fgbhs2wah@gmail.com
20	Wah Region	FG Public School No.3 (Boys) Wah Cantt	0519314322 24407	fgps3bwah@gmail.com
21	Wah Region	FG Model Public School Wah Cantt	0514531457	fg.mhs.1st.wah@gmail.com

22	Wah Region	FG Public School No.1 (Boys) Wah Cantt	05149314327	fgboyspublich@gmail.com
23	Rawalpindi Region	FG Public School (Boys) Peshawar Road Rawalpindi	051-9278175	fgpsbpr@hotmail.com
24	Rawalpindi Region	FG Public School (Boys) Peshawar Road Rawalpindi	0519334745	fgbss2ndshiftpwrrd.rwp@gmail.com
25	Rawalpindi Region	FG Public School (Boys) Nai Chawni Rawalpindi	051-9334373	bss_naichawni@yahoo.com
26	Rawalpindi Region	FG Public School (Boys) Nai Chawni Rawalpindi	051-9334575	fgbss2ndnc@gmail.com
27	Rawalpindi Region	FG Public School (Girls) MH Road Rawalpindi	051 - 9270479 -	fgghs124mhr@gmail.com
28	Rawalpindi Region	FG Public School (Boys) RA Bazar Rawalpindi	051-9270470	fgbhsrabz@gmail.com
29	Rawalpindi Region	FG Public School CMT&SD Golra Rawalpindi	0510321578100 03215781008	fgpss2ndshiftcmt@gmail.com
30	Rawalpindi Region	FG Public School (Girls) Abbottabad	0992-9310120	fgpsgatd@gmail.com

31	Rawalpindi Region	FG Public School (Boys) Abbottabad	09929310121	fgbpsatd@gmail.com
32	Rawalpindi Region	FG Public School (Girls) AMC Centre Abbottabad	0992-9310122	principalfgpublicschoolamcatd@gmail
33	Rawalpindi Region	FG Public School (Boys) Piffers Abbottabad	0992-9310134 0992-330650 f	pifferhs.atd@gmail.com
34	Rawalpindi Region	FG JAS Public School PMA Kakul Abbottabad	0992401049 00	fgjaspspmaatd@gmail.com
35	Rawalpindi Region	FG Public School Tarbela	0995-660760 NIL	fgtarbela@gmail.com
36	Rawalpindi Region	FG Public School Attock	0579316171	fgphs_atk@yahoo.com
37	Rawalpindi Region	FG Public School (Girls) Attock	057-9316162 0	fggirlsattock@gmail.com
38	Rawalpindi Region	FG Public School Mansar Camp Attock	0572702071	fghs.mnsr.ak@gmail.com
39	Rawalpindi Region	FG Public School Mehfooz Road Rawalpindi	051-9270487 0333-5146039	fgpssmr@yahoo.com
40	Rawalpindi Region	FG Public School (Girls) Abid Majeed Road Rawalpindi	0519270494	girlshighamr@yahoo.com

41	Rawalpindi Region	FG Public School (Girls) Abid Majeed Road Rawalpindi	0519271298 0	fggps2ndshift.amrrwp@yahoo.com
42	Rawalpindi Region	FG Public School (Girls) Misrial Road Rawalpindi	0519278148	fgghs_misrialroad@yahoo.com
43	Rawalpindi Region	FG Public School (Girls) Nai Chawni Rawalpindi	051-8482699 03325902762	fgghswestridge@gmail.com
44	Rawalpindi Region	FG Public School (Girls) Ch.Iqbal Road Rawalpindi	051-9270480	fggshchiqrdrwp@gmail.com
45	Rawalpindi Region	FG Public School (Girls) Ch Iqbal Road Rawalpindi	051-9334480 NIL	fgghschiqbalrd2@gmail.com
46	Rawalpindi Region	FG Public School Mehfooz Road, Rawalpindi	0515565801	fgps2mehfoozroad@yahoo.com
47	Rawalpindi Region	FG Public School (Girls) Kashmir Road Rawalpindi	051-9270478	fgghskr@gmail.com
48	Rawalpindi Region	FG Public School (Girls) Daryabad Rawalpindi	0515770647 Nil	fgdghs512@gmail.com
49	Rawalpindi Region	FG Public School (Boys) Daryabad Rawalpindi	0515770758	fghsdaryabad@gmail.com

50	Rawalpindi Region	FG Public School (Boys) Attock	057-9316176	fgbhsatk1980@gmail.com
51	Rawalpindi Region	FG Public School CMT & SD Golra Rawalpindi	9241946	fgphscmt_1st@yahoo.com
52	Rawalpindi Region	FG Public School (Boys) Adamjee Road Rawalpindi	0518313671 nil	fgadamjee@yahoo.com
53	Chaklala Region	FG Higher Secondary School (Girls) COD Kala Jhelum	0544-274654	fgghss1@gmail.com
54	Chaklala Region	FG Public School Morgah Rawalpindi	051-5486388 051-5486388	fgpss.morgah@gmail.com
55	Chaklala Region	FG Public School Morgah Rawalpindi	051-5488538	FGPSSSMORGAH@gmail.com
56	Chaklala Region	FG Public School No.1 (Boys) Tariqabad Rawalpindi	0515422566	fgps1btarwp@gmail.com
57	Chaklala Region	FG Public School (Girls) Tariqabad Rawalpindi	0519270481	fgghsta@gmail.com
58	Chaklala Region	FG Public School (Boys) Marir Hassan Rawalpindi	0514252639	fgpsbmarirhassan@yahoo.com

59	Chaklala Region	FG Quaid-e-Azam Public School Chaklala Scheme-III Rawalpindi	0519280550 -	fgqps86@gmail.com
60	Chaklala Region	FG Quaid-e-Azam Public School Chaklala Scheme-III Rawalpindi	051-55909900	fgqps2@gmail.com
61	Chaklala Region	FG Public School Murree	0513410511	fgpsmurree@hotmail.com
62	Chaklala Region	FG Public School Barian Murree	051-3256633	fghs.bm@gmail.com
63	Chaklala Region	FG Dawood Public School Muzaffarabad (AJK)	05822-960421	fgdpsmzd@gmail.com
64	Chaklala Region	FG Public School Bagh (AJK)	05823-960005 05823-960005	fgpsbagh@gmail.com
65	Chaklala Region	FG Ashiq Hussain Public School Bhimber (AJK)	05828960001	fgps.bhimber@gmail.com
66	Chaklala Region	FG Public School Kotli (AJK)	05826960020	fgpskotli@gmail.com
67	Chaklala Region	FG Public School No.1 (Boys) Jhelum	05449270230	fgbps.jhm@gmail.com
68	Chaklala Region	FG Public School (Girls) Jhelum	0544-9270232	fggpssjlm@gmail.com

69	Chaklala Region	FG Public School No.2 (Boys) Jhelum	(0544)9270233	fgps2bjlm@gmail.com
70	Chaklala Region	FG Sir Syed Public School (Boys) Rawalpindi	0519292718	fgssbssrwp@gmail.com
71	Chaklala Region	FG Sir Syed Public School (Boys) Rawalpindi	0514252211	fgssbss2ndshift@gmail.com
72	Chaklala Region	FG Sir Syed Public School (Girls) Rawalpindi	051-9292719	fgsirsyedgirlsschool@yahoo.com
73	Chaklala Region	FG Sir Syed Public School (Girls) Rawalpindi	051-4252128 0514252128	fgsgss_ii@yahoo.com
74	Chaklala Region	FG Public School (Girls) Lalazar Rawalpindi	0519275041	f.ggpsl@yahoo.com
75	Chaklala Region	FG Public School (Girls) Lalazar Rawalpindi	0519275040	fggphs2lalazar@gmail.com
76	Chaklala Region	FG Public School No.2 (Boys) Tariqabad Rawalpindi	051-5121500 051-5113344	fgthstb1928@gmail.com
77	Chaklala Region	FG Public School No.3 Chaklala Rawalpindi	0519280297 0519280822	fgthsckl2@gmail.com

78	Chaklala Region	FG Public School No.3 (Boys) Chaklala Rawalpindi	0519280822	fg_ths_ckl@yahoo.com
79	Chaklala Region	FG Public School No.1 (Girls) Chaklala Rawalpindi	051-9280389	naqviizahra@gmail.com
80	Chaklala Region	FG Public School No.2 (Girls) Chaklala Rawalpindi	051-9280821	fgps2ckl@yahoo.com
81	Chaklala Region	FG Public School No.2 (Girls) (2nd Shift) Chaklala Rawalpindi	051 9280709 NIL	fgpsno22ndg@gmail.com
82	Chaklala Region	FG Public School No.1 (Boys) Chaklala Rawalpindi	0519280418	fgbhs01@gmail.com
83	Chaklala Region	FG Public School No.2 (Boys) Chaklala Rawalpindi	051-9334487	fgbps2ckl@gmail.com

APPENDIX B

Questionnaire

Respected Teachers: This questionnaire is about Physics Practicum Preparation and Assessment at Secondary School Level and Facts and Challenges about it. This Questionnaire will be used in research of my M. Phil thesis.

- Please respond by ticking the appropriate box.
- There are six seven sections in this questionnaire. First one about Awareness and implementation of standards and benchmarks set in National Curriculum 2006, second about preparation practices of Physics practicum in schools, third about assessment practices of practicum examination, forth about apparatus, facilities and teacher training for Physics practicum fifth about attitude of stake holders about Physics practicum and sixth section consist of two open ended questions about implementation of Physics practicum.
- There are five options in Likert scale. Tick √ to appropriate symbol.

Name_____ Qualification_____

Teaching Experience_____ Name of Institute_____

		strongly disagree	disagree	Un decided	agree	Strongly agree
Awareness and implementation of standards and benchmarks set in National Curriculum 2006						
1	Teachers have awareness about standard and benchmarks set in National curriculum of Physics 2006.	☐	☐	☐	☐	☐
2	Physics practicum work at secondary level meets with the standards set in National curriculum of Physics 2006.	☐	☐	☐	☐	☐
3	Learning objectives set in National Curriculum of Physics 2006 are achievable.	☐	☐	☐	☐	☐
4	Physics course content help in achieving the learning objectives given in national curriculum of Physics, 2006.	☐	☐	☐	☐	☐
5	Physics practicum is implemented in secondary school laboratories according to	☐	☐	☐	☐	☐

	spirit of National curriculum of Physics 2006.					
Preparation practices of practicum in schools						
6	Students are given access for apparatus in laboratory.	☐	☐	☐	☐	☐
7	Students are given opportunities to perform Physics practicum independently.	☐	☐	☐	☐	☐
8	Teachers encourage students for asking questions.	☐	☐	☐	☐	☐
9	Teachers regularly take students to laboratory for practicum.	☐	☐	☐	☐	☐
10	Teachers check practical note books of students on regular basis.	☐	☐	☐	☐	☐
Assessment practices of practicum Examination						
11	Physics practicum has sufficient marks weightage in annual board examinations.	☐	☐	☐	☐	☐
12	Practicum examiners mostly asked viva vice questions related to memorization of facts.	☐	☐	☐	☐	☐
13	Teachers assess learning outcomes set in national curriculum of Physics, 2006 during practicum examinations**.**	☐	☐	☐	☐	☐
14	Apparatus is provided to students for performing of experiment during practicum examinations.	☐	☐	☐	☐	☐
15	Students can successfully explain the data that they have computed during practicum.	☐	☐	☐	☐	☐
Apparatus, Class size and teachers training for Practicum.						
16	There are separate physics laboratories in schools.	☐	☐	☐	☐	☐

17	Available apparatus in laboratories are in proper working conditions.	☐	☐	☐	☐	☐
18	Class size for Physics practicum in secondary schools is suitable	☐	☐	☐	☐	☐
19	Time allocated from Physics practicum in time table is sufficient.	☐	☐	☐	☐	☐
20	Teachers pre-service training emphasized on practicum.	☐	☐	☐	☐	☐
Attitude of stake holders for Physics Practicum						
21	Approaches are made to practical examiners for good practicum marks.	☐	☐	☐	☐	☐
22	Teachers focus more on theory than practicum.	☐	☐	☐	☐	☐
23	Students focus more on theory than practicum.	☐	☐	☐	☐	☐
24	Practicum examiners conduct practicum examinations according to its true spirit.	☐	☐	☐	☐	☐
25	School principals encourage teachers for quality practicum.	☐	☐	☐	☐	☐

I. What are the barriers in implementations of Physics practicum at secondary school level?

……
……
……
……

II. What are your suggestions for proper implementation of Physics practicum at secondary school level?

……
……
……
……

APPENDIX C

Physics Practicum Preparation and Assessment at Secondary School Level:Facts and Challenges

Subject: Request for Validity Certificate

Respected Sir/Madam

I have attached my questionnaires developed for the purpose of research titled as "Physics practicum preparation and assessment at secondary school level:facts and challenges".

- Questionnaire is developed to find about awareness and implementation of standard and benchmark set in national curriculum of physics 2006.
- Questionnaire is also developed to find facts and challenges about assessment of practical work at secondary level.
- Questionnaire is also developed to find facts and challenges about infrastructure and facilities for practical work at secondary level.
- Questionnaire is also developed to assess students learning attitude and behavior for physics practicum.
- Questionnaire is also developed to find facts and challenges about practices of school regarding laboratory work.

Kindly check my questionnaires, its content and construction, provide your valuable suggestions for its improvement and certify its validity by filling the certificate attached at the end of the document.

Muhammad imtiaz

M.Phil Scholar, Deptt of Education,

National University of Modern Languages,

Islamabad, Pakistan

APPENDIX D

CERTIFICATE OF VALIDITY

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

By Mr. Muhammad Imtiaz,
M.Phil Scholar, Department of Education, Faculty of Social Sciences
National University of Modern Languages, H-9, Islamabad, Pakistan

This is to certify that the questionnaire developed by the scholar towards his thesis has been assessed by me and I find it to have been designed adequately to assess about Physics practicum preparation and assessment at secondary school level: Facts and challenges. The questionnaire has dimension for awareness and implementation of standards and benchmarks set in national curriculum for physics 2006, assessment of practical work, infrastructure and facilities about practical work, students learning attitude and behaviour for physics practicum and practices of school regarding laboratory work.

It is considered that the research instrument, developed for the research above titled is according to the objectives and hypothesis of the research, assures adequate construct and content validity according to the purpose of research, and can be used for data collection by the researcher with fair amount of confidence.

Name _____

Designation _____

Institute _____

Signature _____

APPENDIX E

Certificate for Tool Validation
(Likert Scale)

CERTIFICATE OF VALIDITY

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

By Mr. Muhammad Imtiaz,
M.Phil Scholar, Department of Education, Faculty of Social Sciences
National University of Modern Languages, H-9, Islamabad, Pakistan

This is to certify that the questionnaire developed by the scholar towards his thesis has been assessed by me and I find it to have been designed adequately to assess about Physics practicum preparation and assessment at secondary school level: Facts and challenges. The questionnaire has dimension for awareness and implementation of standards and benchmarks set in national curriculum for physics 2006, preparation of practical work, assessment of practical work, infrastructure and facilities about practical work, students learning attitude and behaviour for physics practicum and principal's attitude towards laboratory work.

It is considered that the research instrument, developed for the research above titled is according to the objectives and hypothesis of the research, assures adequate construct and content validity according to the purpose of research, and can be used for data collection by the researcher with fair amount of confidence.

Name Dr. Yasir Hussain

Designation Assistant Professor

Institute NUML, Islamabad

Signature

CERTIFICATE OF VALIDITY

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

By Mr. Muhammad Imtiaz.
M.Phil Scholar, Department of Education, Faculty of Social Sciences
National University of Modern Languages, H-9, Islamabad, Pakistan

This is to certify that the questionnaire adapted by the scholar towards his thesis has been assessed by me and I find it to have been designed adequately to assess about Physics practicum preparation and assessment at secondary school level: Facts and challenges. The questionnaire has dimension for awareness and implementation of standards and benchmarks set in national curriculum for physics 2006, assessment of practical work, infrastructure and facilities about practical work, students learning attitude and behaviour for physics practicum and practices of school regarding laboratory work.

It is considered that the research instrument, adapted for the research above titled is according to the objectives and hypothesis of the research, assures adequate construct and content validity according to the purpose of research, and can be used for data collection by the researcher with fair amount of confidence.

Name Dr. Quratulain

Designation Assistant Professor

Institute PMAS Arid Agriculture University, Rawalpindi

Signature Quratulain

CERTIFICATE OF VALIDITY

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

By Mr. Muhammad Imtiaz,
M.Phil Scholar, Department of Education, Faculty of Social Sciences
National University of Modern Languages, H-9, Islamabad, Pakistan

This is to certify that the questionnaire developed by the scholar towards his thesis has been assessed by me and I find it to have been designed adequately to assess about Physios practicum preparation and assessment at secondary school level: Facts and challenges. The questionnaire has dimension for awareness and implementation of standards and benchmarks set in national curriculum for physics 2006, assessment of practical work, infrastructure and facilities about practical work, students learning attitude and behaviour for physics practicum and practices of school regarding laboratory work.

It is considered that the research instrument, developed for the research above titled is according to the objectives and hypothesis of the research, assures adequate construct and content validity according to the purpose of research, and can be used for data collection by the researcher with fair amount of confidence.

Name

Designation Assistant Prof

Institute PMAS Arid Agric Rwp

Signature

CERTIFICATE OF VALIDITY

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

By Mr. Muhammad Imtiaz,
M.Phil Scholar, Department of Education, Faculty of Social Sciences
National University of Modern Languages, H-9, Islamabad, Pakistan

This is to certify that the questionnaire developed by the scholar towards his thesis has been assessed by me and I find it to have been designed adequately to assess about Physics practicum preparation and assessment at secondary school level: Facts and challenges. The questionnaire has dimension for awareness and implementation of standards and benchmarks set in national curriculum for physics 2006, assessment of practical work, infrastructure and facilities about practical work, students learning attitude and behaviour for physics practicum and practices of school regarding laboratory work.

It is considered that the research instrument, developed for the research above titled is according to the objectives and hypothesis of the research, assures adequate construct and content validity according to the purpose of research, and can be used for data collection by the researcher with fair amount of confidence.

Name Saima Kashif

Designation Lecturer

Institute AIOU

Signature

APPENDIX F

NATIONAL UNIVERSITY OF MODERN LANGUAGES
FACULTY OF SOCIAL SCIENCES
DEPARTMENT OF EDUCATION

ML.1-4/2020/Edu

Dated: 20-01-2020

To: **Muhammad Imtiaz,**
1491-MPhil/Edu/S18

Subject: **APPROVAL OF MPHIL THESIS TOPIC AND SUPERVISOR**

1. Reference to Minute Sheet No. ML.1-2/2020-Edu dated 02-1 -2020, the Higher Authority has approved your topic and supervisor/s on the recommendation of Faculty Board of Studies vide its meeting held on 15th Oct 2019.

a. **Supervisor's Name & Designation**
Dr. Khush Bakht Hina,
Assistant Professor, Department of Education
NUML, Islamabad.

b. **Topic of Thesis**

Physics Practicum Preparation and Assessment at Secondary School Level: Facts and Challenges

2. You may carry out research on the given topic under the guidance of your Supervisor/s and submit the thesis for further evaluation within the stipulated time. It is to inform you that your thesis should be submitted within the prescribed period by **31st Jan 2021** positively for further necessary action please.

3. As per policy of NUML, all MPhil/PhD theses are to be run through Turnitin by QEC of NUML before being sent for evaluation. The university shall not take any responsibility for high similarity resulting due to thesis prior run by any other individual.

4. Thesis is to be prepared strictly on NUML's format that can be taken from the MPhil & PhD Coordinator, Department of Education.

Telephone No: 051-9265100-110 Ext: 2090
E-mail: mdin@numl.edu.pk

Dr. Hukam Dad Malik
Head,
Department of Education

Cc to:
Dr. Shazia Zamir
Dr. Farkhanda Tabbassum

APPENDIX G

National Curriculum for

PHYSICS

Grades IX – X

2006

GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD

List of Contents

PART-I PREAMBLE

INTRODUCTION

The secondary school education is crucial and challenging, being a transition level from general science to discipline based curriculum. At this level, the students take up physics, as a discipline, with a purpose of pursuing their future careers in basic sciences or pre-professional courses like medicine, engineering and technology at the higher level. Hence, there is a need to provide the learners with sufficient conceptual background of physics which would eventually make them competent to meet the challenges of academic and pre-professional courses after the secondary level.

RATIONALE

The present effort of revising and updating the physics curriculum is an exercise based on the feedback received on the curriculum and course material in vogue, expansion of frontiers of physics knowledge, a paradigm shift due to emerging trends of teaching - learning process towards interactive and participative approach, making a student an active and independent learner.

The structure of the syllabus is based on logical sequencing of the subject matters kept by proper placement of the concepts, appropriate to the comprehension level of the students. Due care has been taken that the syllabus is not heavy and at the same time, it is comparable to the international standards. Curriculum load has been reduced by eliminating overlapping of concepts within the discipline of physics or with other disciplines making room for contemporary core topics and emerging curricular areas. The scientific method has been practiced as a method of inquiry in a way that stimulates curiosity and interest. Every opportunity has been taken to expose the students to the applications of physics to technology and environmental issues. Emphasis has been given to promote process-Investigation Skills/ Laboratory work, problem-solving abilities and application of concepts, useful in real life situations for making physics learning more relevant, meaningful and stimulating.

CURRICULUM DEVELOPMENT STRATAGEM

1. Formation of Curriculum Development Team comprising of Experts from diverse areas of education such as Subject Specialists of Punjab Textbook Board, former Curriculum Research & Development Centre (CRDC), Provincial Institute of Teacher Education (PITE), Directorate of Staff Development (DSD), Teachers, Educators, Working School and College Teachers of public schools as well as of private schools.
2. Orientation and training workshops/seminars on curriculum development.
3. Consultative meeting with students / working teachers, professors to get feedback and comments on existing curriculum.
4. The need assessment by critically reviewing of current curriculum, extensive field survey to seek feedback/ comments from students, teachers and other stakeholders.

5. Analysis of feedback received by Punjab Textbook Board and Curriculum Wing, Islamabad.
6. Downloading of 18 international curriculum documents from the internet/websites.
7. Study of foreign curricula for comparison and guidelines.
8. Determination of philosophy of curriculum design, aims and objectives, standards and benchmarks.
9. Drafting of core syllabus: The structure, units, contents, learning outcomes with time frame and weighting including identification of investigations / practicals and demonstrations, assessment objectives and pattern.
10 Drafting suggestions on the other components of curriculum such as

   (a) Instructions for writing teaching-learning materials/ textbooks,
   (b) Concept mapping
   (c) Teaching strategies and methodology
   (d) Teachers training

11. Identification of salient features of National Physics Curriculum.

NEED ASSESSMENT

The necessity to revise and update physics curriculum is based on the aspirations of our Government and the people visualizing a vibrant and responsive curriculum comparable with international standards. A curriculum which can meet the challenges of the era of knowledge driven economies as well as grooming the younger generation into dynamic, responsible and productive citizens of this technological world. The feedback received in the Punjab Textbook Board during the last three years on the curriculum and course material in vogue is another factor supporting the same cause. In addition to that an extensive field survey for the purpose of need assessment was carried out to seek comments and suggestions on physics curriculum from the students, teachers and other stakeholders.

Data about the modern trends in the process of curriculum revision, the world over, were downloaded and analyzed. Newspaper articles, columns and reports were also collected to ensure a reflexive involvement of stakeholders.

The following field study reports were carefully examined and analyzed before launching work on the draft curriculum

1 Feedback analysis from Field Survey of the following schools by Mr. C.D. Arif, Additional Director (Curriculum Wing), Punjab Textbook Board.
   (a) Govt. Pilot Secondary School (Boys), Wahdat Road, Lahore
   (b) Govt. Pilot Secondary School (Girls), Wahdat Road, Lahore
   (c) Govt. Boys High School , Karim Block, AIT, Lahore
2 Critical Review of National Curriculum Physics IX-X (2000) by Mr.Majahid Haider, Beaconhouse School System

3 Critical Review of National Curriculum Physics IX-X (2000) by Mrs. Nazma Sheikh, S.S.S. (Physics), Punjab Textbook Board, Lahore

4 Feedback from Students and Teachers Crescent Model School Lahore by Mr. M.Shakoor, Headmaster.

5 Feedback from students and teachers by Mr. Muhammd Ismail Zareef, Crescent Model Higher Secondary School, Lahore

6 Feedback from Students and Teachers Govt. Pilot Secondary School, Wahdat Road, Lahore by Mr. Muhammad Firdious, S.S.T.

The committee identified the following focussing areas:

1. Elimination of vertical overlapping within the discipline and horizontal overlapping with other disciplines.
2. Linkage to be established horizontally with other disciplines and vertically within the discipline.
3. Modern trends and development to be incorporated.
4. Relevance of concepts with students own experience, observations and environment.
5. Identification of re-sequencing of some concepts.
6. Provision of conducive environment for enjoyable and thrilling learning experiences.
7. Stimulating students curiosity and sense of wonder.
8. Developing, observing, measuring, performing and recording Investigation Skills/ Laboratory work in a context that enables students to experience the joy of doing physics.
9. Emphasis on real life applications of concepts and problem solving techniques.
10. More emphasis on in-depth understanding of a concept rather than breadth.

Need has been realized to restructure the curriculum in the light of above study reports/feedback so that the thinking abilities and Investigation Skills/ Laboratory work becomes the vehicle for acquiring scientific knowledge, investigating and problem solving techniques.

COMPARATIVE STUDIES WITH INTERNATIONAL CURRICULA

The Physics Curriculum Team carried out comparative studies of National Curriculum in vogue with the following international curricula before initiating drafting of National Curriculum:

1. Physics GCE O Level 2007, University of Cambridge International Examinations (CIE), U.K.
2. Physics Syllabus, Malta
3. Physics Curriculum Secondary Level, Hong Kong
4. NBSE Physics Curriculum of India for classes IX-X
5. Grades Nine through twelve – Physics, California State Board of Education, U.S.A.
6. Physics Curriculum Guidelines of Ontario, Canada
7. South Australia Certificate of Education Physics Curriculum 2006
8. New South Wales Australia Physics Curriculum 2002

The following international curriculum documents were also downloaded and consulted before initiating work on the draft curriculum:.

1. National Science Curriculum Standards, The Institute for the Promotion of Teaching Science and Technology, Thailand
2. NEBRASKA Science Standards Grades K-12
3. Star Science Standards, Nebraska Department of Education
4. Physics Secondary School Curriculum, State of Utah
5. Michigan State Board of Education Standards and draft Benchmarks (summer 2000)
6. Sequoia Union High School District Physics Curriculum Guide (U.S.A.)
7. Mississippi Science Framework 2001 U.S.A.
8. Science Curriculum Reforms in U.S.A.
9. Coal city High School Physics Curriculum, U.S.A.
10. San Ramon Valley Unified School District 2002 Physics Curriculum Grades 9-12, U.S.A.

PART-II CONTENTS

VISION STATEMENT

Promotion of process skills, problem solving abilities and application of concepts, useful in real life situation for making physics learning more relevant, meaningful and stimulating.

AIMS

The aims of the physics course at secondary school level are to enable student to:

1. develop interest, motivation and sense of achievement in the study of physics
2. develop the ability to describe and explain concepts, principles, systems, processes and applications related to physics.
3. develop the thinking process, imagination, ability to solve problems, data management, investigating and communication skills.
4. develop an attitude of responsible citizenship, including respect for the environment and commitment to the wise use of resources.
5. recognize the usefulness and limitations of scientific method and the interaction between science, technology and society

SYLLABUS DESIGN

The syllabus is designed to emphasize less on purely factual material, but a much greater emphasis on the understanding and application of physics concepts and principles. This approach has been adopted in recognition of the need for students to develop Investigation Skills/ Laboratory work that will be of long term value in an increasingly technological world.

The syllabus framework is based on the **standards** and **benchmarks** framed by National Curriculum Council. It comprises of five main themes/sections with overview of each section. Each section is further divided into "units" showing their conceptual linkages.

In order to specify the syllabus as precisely as possible and also to emphasize the importance of higher order abilities and Investigation Skills/ Laboratory work other than recall, **learning outcomes** have been used throughout. Each unit of the syllabus is specified by **content section / major concepts** followed by detailed **learning outcomes**. The intended level and scope of treatment of a content is defined by the stated **learning outcomes** with easily recognizable domain of (i) **recalling** (ii) **understanding** (iii) **applying** (iv) **analyzing** (v) **evaluating** (vi) and **creating**, Under the subhead "**Investigation Skills/ Laboratory work**" measuring, observing, manipulating, recording and interpreting /analyzing, predicting and **communicating abilities/ Investigation Skills** are expected to be developed through related **investigations, activities and practical work**.

The relevance and significance of concepts to students everyday life and to the natural and man made world is given under the subhead "**science, technology and society connections**". This section preferably be delivered through novel questions or numerical problems based on real life experiences. The applications which are slightly of higher level may be tackled through guided inquiry approach.

Unit-wise weighting and time allocation for each chapter has been proposed. A separate list of standard practicals, and required equipment is given. Assessment pattern has also been included in the curriculum document.

STANDARDS, BENCHMARKS AND LEARNING OUTCOMES

In the 21st century, students will remain the most important natural resource to ensuring the continual improvement and ultimate progress of humankind. It is critical that all involved in education prepare students to meet the challenges of a constantly changing global society. It is time to call for a raising in the expectations of student learning.

Preparing students for success in the new millennium and beyond, calls for increasing rigor and relevance in the curriculum. In adult roles, individuals are expected to work with others in a team setting, have an acquired knowledge base, be able to extend and refine knowledge, be able to construct new knowledge and applications and have a habit of self-assessing their assimilation of each dimension in their everyday decision making process.

This curriculum document is built upon Standards, Benchmarks, and Learning Outcomes for the benefit of student growth and progress.

STANDARDS are what students should know and be able to do. Standards are broad descriptions of the knowledge and skills students should acquire in a subject area. The knowledge includes the important and enduring ideas, concepts, issues, and information. The skills include the ways of thinking, working, communication, reasoning, and investigating that characterize a subject area. Standards may emphasize interdisciplinary themes as well as concepts in the core academic subjects.

Standards are based on:

- *Higher Order Thinking:* instruction involves students in manipulating information and ideas by synthesizing, generalizing, explaining or arriving at conclusions that produce new meaning and understanding for them.

- *Deep Knowledge:* instruction addresses central ideas of a topic or discipline with enough thoroughness to explore connections and relationships and to produce relatively complex understanding.

- *Substantive Conversation:* Students engage in extended conversational exchanges with the teacher and / or peers about subject matter in a way that builds an improved and shared understanding of ideas or topics.

- *Connections to the World Beyond the Classroom:* Students make connections between substantive knowledge and either public problems or personal experiences.

BENCHMARKS indicate what students should know and be able to do at various developmental levels. Our benchmarks are split into 5 developmental levels:

- Kachi to Grade 3
- Grade 4 to Grade 5
- Grade 6 to Grade 8
- Grade 9 to Grade 10
- Grade 11 to Grade 12

LEARNING OUTCOMES indicate what students should know and be able to do for each topic in any subject area at the appropriate developmental level. The Learning Outcomes sum up the total expectations from the student. Within this document the Learning Outcomes are presented under three subheadings:

- ☼ Understanding
- ☼ Skills including laboratory work
- ☼ Science, Technology and Society connections

The Standards and the accompanying Benchmarks will assist in the development of comprehensive curriculum, foster diversity in establishing high quality Learning Outcomes, and provide an accountability tool to individuals involved in the education market place. These provide a common denominator to determine how well students are performing and will assure that all students are measured on the same knowledge and skills using the same method of assessment.

PHYSICS STANDARDS AND BENCHMARKS FOR GRADES IX-XII

The content standards provide descriptions of what students should know, understand and be able to do in a specific content area.

In addition, benchmarks in each content areas are drafted to further clarify the content standards. They define our expectations for students knowledge, skills and abilities along a development continuum in each content area. They are meant to define a common denominator to determine how well students are performing.

(A) Constructing New Scientific Knowledge

Scientifically literate students are learners as well as user of knowledge. They ask question about the world that can be answered by using scientific knowledge and techniques. They can also develop solutions to problems that they encounter or questions they ask. They can remember key points and use sources of information to reconstruct previously learnt knowledge, rather than try to remember every detail of what they learnt.

Standard 1.

Students will be able to display a sense of curiosity and wonder about the natural world and demonstrate an increasing awareness that this has lead to new developments in science and technology.

(B) Reflecting on scientific knowledge

Scientifically literate students can show an appreciation for scientific knowledge and the patterns that reveal in the world; this often involves seeing connections among different areas of knowledge. They may be able to take a historical and cultural perspective on concepts and theories or to discuss relationships among science, technology and society.

Standard 2.

Students will be able to demonstrate an understanding of the impact of science and technology on society and use science and technology to identify problems and creatively address them in their personal, social and professional lives.

(C) Using scientific knowledge

Scientifically literate students can use their knowledge to understand the world around them and to guide their actions. Important type of activities that use scientific knowledge include description and explanation of real world objects, systems or events; prediction of future events or observations; and the design of systems or courses of action that enable people to adopt to and modify the world around them.

Standard 3.

Student will be able to understand the processes of scientific investigation. They will be able to identify a problem, design and conduct experiments and communicate their findings using a variety of conventional and technological tools.

Standard 4.

Students will be able to describe and explain common properties, forms and interactions of energy and matter, their transformations and applications in physical systems.

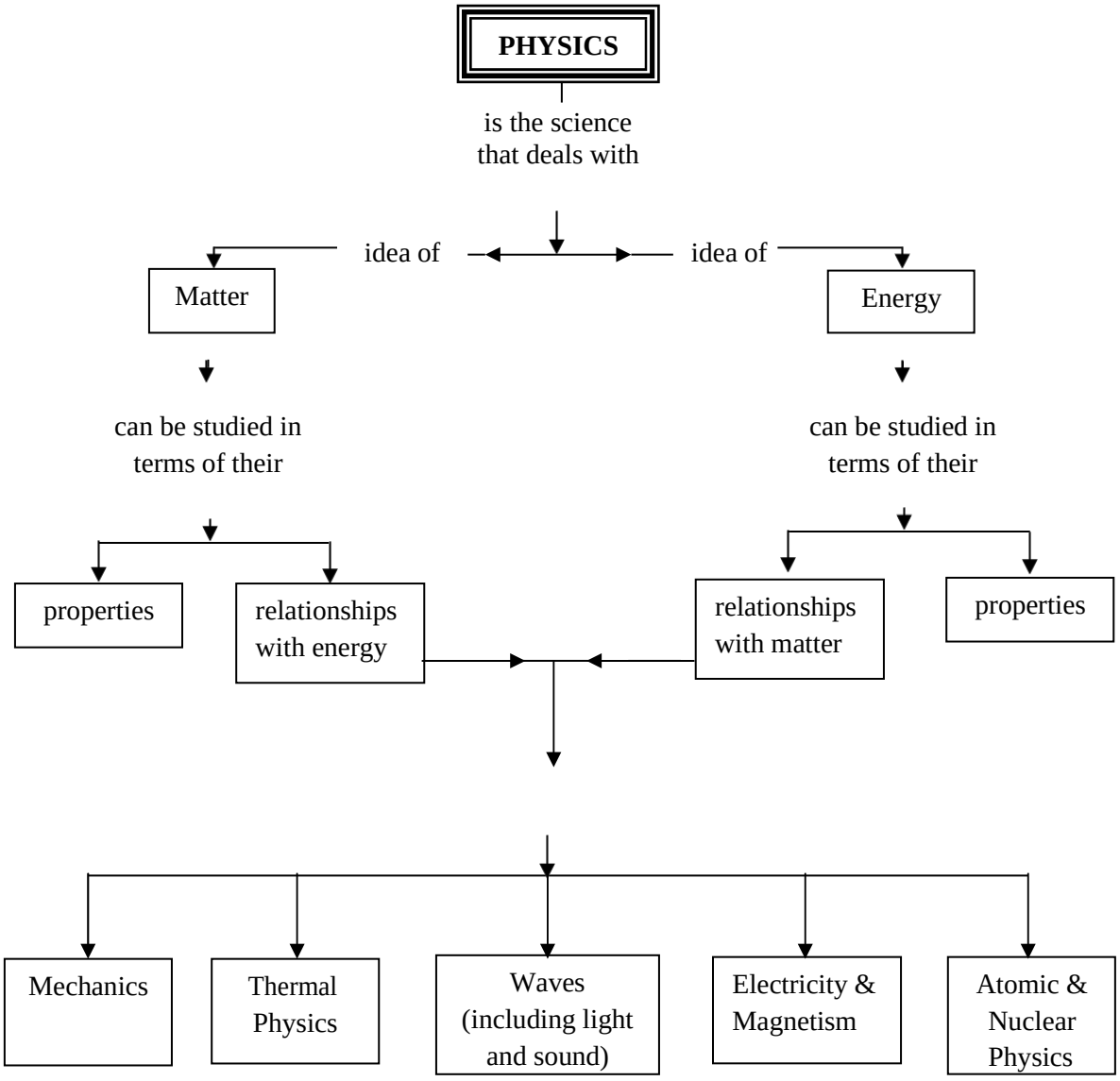
BENCHMARKS

Standard Code	Benchmarks Secondary Level	Benchmarks Higher Secondary Level
	At the end of the course, the students will:	**At the end of the course, the students will:**
1.1	Generate scientific questions about the world based on observation.	Ask questions that can be investigated empirically.
1.2	Develop solutions to problems through reasoning, observation, and investigations.	Develop solutions to problems through reasoning, observation, and investigations.
1.3	Design and conduct scientific investigations	Design and conduct scientific investigations.
1.4	Use tools and equipment appropriate to scientific investigations.	Recognize and explain the limitations of measuring devices.
1.5.	Use metric measurement devices to provide consistency in an investigation.	Gather and synthesize information from books and other sources of information.
1.6	Use sources of information in support of scientific investigations.	–
1.7	Write and follow procedures in the form of step-by-step instructions, formulae, flow diagrams, and sketches.	Discuss topics in groups by making clear presentations, restating or summarizing what others have said, asking for clarification or elaboration, taking alternative perspectives, and defending a position.
2.1	Evaluate the strengths and weaknesses of claims, argument or data.	Justify plans or explanations on a theoretical or empirical basis.
2.2.	Describe limitations in personal knowledge.	Describe some general limitations of scientific knowledge.
2.3	Show how common themes of science, mathematics, and technology apply in real-world contexts.	Show how common themes of science, mathematics, and technology apply in real world contexts.
2.4	–	Discuss the historical development of the key scientific concepts and principles.

2.5	Describe the advantages and risks of new technologies	Explain the social and economical advantages and risks of new technology.
2.6	Develop an awareness and sensitivity to the natural world.	Develop an awareness and sensitivity to the natural world.
2.7	Recognize the contributions made in science by cultures and individuals of diverse backgrounds.	Describe the historical, political and social factors affecting developments in science.
3.1	Understand inquiry principles and process of 1st hand investigation in Physics.	Appreciate the ways in which models, theories and laws in physics have been tested and validated
3.2	Describe applications of physics which affect society or the environment.	Assess the impacts of applications of physics on society and the environment.
3.3	Select and use appropriate equipment for investigation plan.	Justify the appropriateness of a particular investigation plan.
3.4	Identify methods, collecting and recording data, and also organizing and analyzing data.	Identify ways in which accuracy and reliability could be improved in investigations.
3.5	Use appropriate terminology and reporting styles to communicate information and understanding in physics.	Use terminology and report styles appropriately and successfully to communicate information.
3.6	Draw valid conclusions from gathered data and information.	Assess the validity of conclusions from gathered data and information.
4.1	Describe the forces acting on an object which causes changes in its motion.	Explain events in terms of Newton's laws and law of conservation of momentum.
4.2	Describe the effects of energy transfers and energy transformations.	Explain the effects of energy transfers and energy transformations.
4.3	Describe modular model of matter and its understanding to explain various concepts related the behaviour of matter.	Explain mechanical, electrical and magnetic properties of solids and their significance.
4.4	Demonstrate an understanding of the principles related to fluid statics and appreciate their use	Demonstrate an understanding of the principles related to fluid dynamics and their applications.

	in hydraulic systems.	
4.5	Investigate and explain heat transfers by conduction, conversion and radiation and their consequences.	Explain that heat flow and work are two forms of energy transfers between systems and their significance.
4.6	Explain wave motions in terms of energy sources and the oscillations produced.	Understand wave properties, analyze wave interactions and explain the effects of those interactions.
4.7	Show understanding of geometrical optics by experimenting and exploring reflection and refraction of light and make use of them in spherical mirrors and lenses.	Demonstrate an understanding of wave model of light as e.m waves and describe how it explains diffraction patterns, interference and polarization.
4.8	Describe the relationship between force and potential energy in gravitational and electrical fields.	Explain the effects of electric, magnetic and gravitational fields.
4.9	Show understanding of electric current and potential difference and calculate electric energy consumption of appliances and demonstrate safety measures in home circuitry.	Demonstrate and understand the properties, physical quantities, principles and laws related to electricity and magnetism and make use of them.
4.10	Investigate and state basic properties of some electronic and communication components and make basic electronic circuit and make use of it.	Investigate and explain basic properties of semi-conductors devices (diodes and transistors) and make electronic circuits and make use of them.
4.11	Describe and explain the structure of atom and atomic nucleus, origin of radioactivity, its uses and hazards.	Search, for information and explain nuclear reactions, fission, fusion, interaction between matter and energy benefits and risks of nuclear energy. Describe quantum theory, special theory of relativity and other modern concepts in Physics.

Concept Map of Physics IX – X



In the fields (not exhaustive) of

LIST OF SECTIONS & UNITS IX-X

Section-1	Mechanics	1. Physical quantities and measurement
		2. Kinematics
		3. Dynamics
		4. Turning effect of forces
		5. Gravitation
		6. Work and Energy
		7. Properties of matter
Section-2	Heat	8. Thermal properties of matter
		9. Transfer of heat
Section-3	Oscillations and Waves	10. Simple harmonic motion and waves
		11. Sound
		12. Geometrical optics
Section-4	Electricity and Magnetism	13. Electrostatics
		14. Current electricity
		15. Electromagnetism
		16. Introductory electronics
		17. Information & communication Technology
Section-5	Atomic & Nuclear Physics	18. Radioactivity

Section 1 Mechanics

Overview: In this section, fundamental concepts of mechanics are introduced. Students are expected to possess experimental Investigation Skills/ Laboratory work in time measurement and in the recording of displacement, velocities and acceleration of objects using suitable measuring instruments. Investigation Skills/ Laboratory work in the measurement of masses, weights and forces are also required. Data handling Investigation Skills/ Laboratory work such as the conversion of displacement data into information on velocity or acceleration are expected. Students should be able to display experimental results in an appropriate form, interpret and analyse motion and draw valid conclusions. In particular, students should be able to plot graphs with an appropriate scale and interpret the significance of slopes, intercepts and areas in certain graphs.

The characteristics of gravitational force are also examined in this section. Newton's law of universal gravitation is introduced and used to extend the study of uniform circular motion to the centripetal acceleration caused by the gravitational force on a satellite.

UNIT # 1 Physical Quantities and Measurement

The following concepts are developed in this unit. Their intended level and scope is defined by the learning outcomes.

Major Concepts (21 periods)

- Introduction to Physics
- Physical quantities
- International system of units
- Prefixes (multiples and sub multiples)
- Standard form / scientific notation
- Measuring instruments
    1. metre rule
    2. vernier callipers
    3. screw gauge
    4. physical balance
    5. stopwatch
    6. measuring cylinder
- An introduction to significant figures

Conceptual linkage:

- This chapter is built on Measurement – Science-VIII. Scientific Notation Maths IX

- This chapter leads to:

✑ Learning outcomes:

Understanding

The students will:

- describe the crucial role of Physics in Science, Technology and Society.
- explain with examples that Science is based on physical quantities which consist of numerical magnitude and a unit.
- differentiate between base and derived physical quantities.

- list the seven units of System International (SI) alongwith their symbols and physical quantities (standard definitions of SI units are not required).
- interconvert the prefixes and their symbols to indicate multiple and sub-multiple for both base and derived units.
- write the answer in scientific notation in measurements and calculations.
- describe the working of vernier callipers and screw gauge for measuring length.
- identify and explain the limitation of measuring instruments such as metre rule, vernier callipers and screw gauge.
- describe the need using significant figures for recording and stating results in the laboratory.

☞ Investigation Skills/ Laboratory work

The students will:

- compare the least count/ accuracy of the following measuring instruments and state their measuring range:
    i. Measuring tape
    ii. Metre rule
    iii. Vernier callipers
    iv. Micrometer screw gauge
- make a paper scale of given least count e.g. 0.2 cm and 0.5 cm.
- determine the area of cross section of a solid cylinder with vernier callipers and screw gauge and evaluate which measurement is more precise.
- measure length and diameter of a cylinder and calculate the volume with a vernier callipers.
- measure the thickness of a metal strip or a wire using a screw gauge.
- determine an interval of time using stopwatch
- determine the mass of an object by using different types of balances and identify the most accurate balance.
- determine volume of an irregular shaped object using a measuring cylinder.
- list laboratory safety equipments and rules.
- use appropriately safety equipments in the laboratory.

☞ Science, Technology and Society Connections

The students will:

- determine length, mass, time and volume in daily life activities using various measuring instruments .
- list with brief description the various branches of physics.

UNIT # 2 Kinematics

Major Concepts (19 periods)

- Rest and motion
- Type of motion (Translatory, rotatory, vibratory)
- Terms associated with motion;
    - Position
    - Distance and displacement
    - Speed and velocity
    - Acceleration
- Scalars and Vectors
- Graphical analysis of Motion;
    - Distance-time graph
    - Speed-time graph
- Equations of Motion;
    - $S = vt$
    - $v_f = v_i + at$
    - $S = v_i t + ½ at^2$
    - $v_f^2 – v_i^2 = 2 a S$
- Motion due to gravity

Conceptual linkage:

- This chapter is built on

  Force and Motion science IV

- This chapter leads to Motion

Learning Outcomes:

Understanding

The students will:

- describe using examples how objects can be at rest and in motion simultaneously.
- identify different types of motion i.e; translatory, (linear, random, and circular); rotatory and vibratory motions and distinguish among them.
- differentiate with examples between distance and displacement, speed and velocity.
- differentiate with examples between scalar and vector quantities.
- represent vector quantities by drawing.
- define the term speed, velocity and acceleration.
- plot and interpret distance-time graph and speed-time graph.
- determine and interpret the slope of distance-time and speed-time graph.
- determine from the shape of the graph, the state of a body.

i. at rest ii. moving with constant speed iii. moving with variable speed.

- calculate the area under speed-time graph to determine the distance traveled by the moving body.
- derive equations of motion for a body moving with a uniform acceleration in a straight line using graph.
- solve problems related to uniformly accelerated motion using appropriate equations.
- solve problems related to freely falling bodies using 10 ms^{-2} as the acceleration due to gravity.

☞ Investigation Skills/ Laboratory work

The students will:

- demonstrate various types of motion so as to distinguish between translatory, rotatory and vibratory motions.
- measure the average speed of a 100 m sprinter
- determine the acceleration of free-fall by timing a falling object by free fall apparatus.
- calculate the acceleration down an inclined surface of an iron ball using angle iron by drawing 2S and t^2 graph.

☞ Science, Technology and Society Connection

The students will:

- list the effects of various means of transportations and their safety issues.
- the use of mathematical slopes (ramps) of graphs or straight lines in real life applications.
- interpret graph from newspaper, magazine regarding cricket and weather etc.

UNIT # 3 Dynamics

Major Concepts (21 periods)

- Momentum
- Newton's laws of motion
- Friction
- Uniform circular motion

Conceptual linkage

This unit is built on
Force-Science IV,

Friction Science V

This unit leads to

➪ Learning Outcomes:

Understanding

The students will:

- define momentum, force, inertia, friction, centripetal force.
- solve problem using the equation Force = change in momentum / change in time.
- explain the concept of force by practical examples of daily life.
- state Newton's laws of motion.
- distinguish between mass and weight and solve problem using F = ma, and w = mg.
- calculate tension and acceleration in a string during motion of bodies connected by the string and passing over frictionless pulley using second law of motion.
- state the law of conversation of momentum.
- use the principle of conservation of momentum in the collision of two objects.
- determine the velocity after collision of two objects using the law of conversation of momentum.
- explain the effect of friction on the motion of a vehicle in the context of tyre surface, road conditions including skidding, braking force.
- demonstrate that rolling friction is much lesser than sliding friction.
- list various methods to reduce friction.
- explain that motion in a curved path is due to a perpendicular force on a body than changes direction of motion but not speed.
- calculate centripetal force on a body moving in a circle using mv^2/r.
- state what will happens to you while you are sitting inside a bus when the bus
  1. starts moving suddenly
  2. stops moving suddenly
  3. turns a corner to the left suddenly
- write a story about what may happen to you when you dream that all frictions suddenly disappeared. Why did your dream turn into a nightmare?"

➪ Investigation Skills/ Laboratory Work

The students will:

- identify the relationship between load and friction by sliding a trolley carrying different loads with the help of a spring balance on different surfaces.
- determine the value of "g" by Atwood's machine.

- investigate the relationship between force of limiting friction and normal reaction to find the co-efficient of sliding friction between a wooden block and horizontal surface.
- determine the force of limiting friction by rolling a roller on a horizontal plane.

✑ Science, Technology and Society Connections

The students will:

- identify the principle of dynamics with reference to the motion of human beings, objects, and vehicles (e.g. analyse the throwing of a ball, swimming, boating and rocket motion).
- identify the safety devices (such as packaging of fragile objects, the action of crumple zones and seatbelts) utilized to reduce the effects of changing momentum.
- describe advantages and disadvantages of friction in real – world situations, as well as methods used to increase or reduce friction in these situations (e.g. advantages of friction on the surface of car tyres (tyre tread), cycling, parachute, knots in string; disadvantages of, and methods for reducing friction between moving parts of industrial machines and on wheels spinning on axles).
- identify the use of centripetal force in (i) safe driving by banking roads (ii) washing machine dryer (iii) cream separator.

LIST OF PRACTICAL FOR IX-X GRADES

Standard experiments

1 To measure the area of cross section by measuring diameter of a solid cylinder with vernier callipers.

2 To measure the volume of a solid cylinder by measuring length and diameter of a solid cylinder with vernier callipers.

3 To measure the thickness of a metal strip or a wire by using a screw gauge.

4 To find the acceleration of a ball rolling down an angle iron by drawing a graph between 2S and T^2.

5 To find the value of "g" by free fall method.

6 Investigate the relationship between force of limiting friction and normal reaction to find the co-efficient of sliding friction between a wooden block and horizontal surface.

7 Measure the force of limiting friction by rolling a roller on a horizontal plane.

8 To determine the value of "g" by the Atwood's machine.

9 To determine the resultant of two forces graphically using a Horizontal force table.

10 To verify the principle of moments by using a metre rod balanced on a wedge.

11 To find the tension in the strings by balancing a metre rod on the stands.

12 To find the weight of an unknown object by using vector addition of forces.

13 To find the weight of an unknown object by using principle of moments.

14 To study the effect of the length of simple pendulum on time and hence find "g" by calculation.

15 To prove that time period of a simple pendulum is independent of (i) mass of the pendulum (ii) amplitude of the vibration.

16 To study the relationship between load and extension (Helical spring) by drawing a graph.

17 To find the density of a body heavier than water by Archimedes principle.

18 To find the density of a liquid using 5 ml syringe (instead of density bottle).

19 To find the specific heat by the method of mixture using polystyrene cups (used as container of negligible heat capacity).

20 To draw a graph between temperature and time when ice is converted into water and then to steam by slow heating.

21 To measure the specific heat of fusion of ice.

22 To verify the laws of refraction by using a glass slab.

23 To find the refractive index of water by using concave mirror.

24 To determine the critical angle of glass using a semi circular slab and a light ray box/or by prism.

25 To trace the path of a ray of light through glass prism and measure the angle of deviation.

26 To find the focal length of a convex lens by parallax method.

27 To set up a microscope and telescope.

28 Verify Ohm's law (using wire as conductor).

29 To study resistors in series circuit.

30 To study resistors in parallel circuit.

31 To find the resistance of galvanometer by half deflection method.

32 To trace the magnetic field using a bar magnet.

33 To trace the magnetic field due to a current carrying circular coil.

34 To verify the truth table of OR, AND, NOT, NOR and NAND gates.

35 To make a burglar alarm/fire alarm using an appropriate gate.

Note:

1. At least 30 standard practical alongwith exercises are required to be performed during the two years of course of studies of grades IX-X.
2. Use of centimetre graph paper be made compulsory.