UNIVERSITY OF EDUCATION, WINNEBA

EFFECT OF PRACTICAL ACTIVITIES ON STUDENTS' PROCESS SKILLS, CONCEPTUAL UNDERSTANDING, AND PERFORMANCE IN MEASUREMENT IN PHYSICS

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MASTER OF PHILOSOPHY

2022

UNIVERSITY OF EDUCATION, WINNEBA

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A Thesis in the Department of Science Education, Faculty of Science Education,
submitted to the School of Graduate Studies in partial fulfilment
of the requirements for the award of the degree of
Master of Philosophy
(Science Education)
in the University of Education, Winneba

DECEMBER, 2022

DECLARATION

STUDENT'S DECLARATION

I, MICHAEL OWUSU, declare that this thesis, with the exception of quotations and references contained in the published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ....

DATE: ....

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: PROFESSOR VICTOR ANTWI

SIGNATURE: ....

DATE: ....

DEDICATION

I dedicate this thesis to my mum and dad, Mrs. Rosemond Owusu and Mr. Thomas Owusu for their prayers and support in my academic journey. Also, a special dedication goes to my lovely wife, Mrs. Linda Owusu and daughter, Michaella Owusu-Nyamekye.

ACKNOWLEDGEMENTS

I am deeply grateful to God Almighty for bestowing me with the strength and perseverance to complete this Thesis. I would like to express my heartfelt appreciation to my supervisor, Professor Victor Antwi, whose invaluable guidance, constructive criticisms, and unwavering encouragement have been instrumental in shaping this research. My gratitude also extends to my loving parents, Mrs. Rosemond Owusu and Mr. Thomas Owusu, for their constant love and support throughout the years, as well as to my family members, particularly Mrs. Linda Owusu and Michaella Owusu-Nyamekye. I am also indebted to Dr. Michael Gyan, Mr. Emmanuel Ahenfo, Mr. Isaac Akwasi Acquah, Mr. John Ray, and Mr. Gilbert Adu for their support and assistance. Furthermore, I extend my appreciation to all the Physics students of Kaleo Senior High Technical School and Queen of Peace Senior High School in the Nadowli-Kaleo District of the Upper West Region, whose participation made this Thesis possible. Once again, I offer my heartfelt thanks to all who have contributed to the completion of this research. May God bless you all.

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ABSTRACT

The study assessed the effect of practical activities on senior high school students' process skills, conceptual understanding and performance in measurement in physics. Students from Form two science studying physics at Kaleo Senior High and Technical School (KASHTS) lack the skills and conceptual understanding in measurement in physics. It became evident when about 80% representing one hundred and seventy (170) students out of the entire physics student's population of two hundred and twelve (212) struggled to apply certain measuring skills and simple concepts in measurement in physics. This led to most of the students showing abysmal performance during practical tests. The objectives of the study were to: identify the process skills students are unable to perform under measurement in physics, determine the pre-conceptual process skills of students in measurement in physics, determine the effect of practical activities on students' conceptual understanding in measurement in physics and assess the effect of practical activities on students' performance in measurement in physics. Action research design was adopted in this study. Purposive sampling was used to select an intact class of forty-nine (49) physics students in Form two at Kaleo Senior High and Technical School in the Upper West Region. The researcher used observational checklist, questionnaires and tests as instruments for the collection of data. These instruments were validated by my supervisor and other specialist in the field of physics whereas a pilot test was conducted at Queen of Peace SHS (40 students) attaining a Cronbach Alpha value of 0.960 representing a higher reliability. Both qualitative and quantitative method of data analysis were employed in this study. The qualitative data were analysed using descriptive statistics whilst the quantitative data were analysed using inferential statistics. Data collected were analysed by applying Paired sample t-test, mean, standard deviation and percentages using statistical package for social science (SPSS) version 26. The findings revealed that students enjoyed practical activities and their post-responses as compared to their pre-responses of the intervention questionnaire indicated an improve conceptual understanding in measurement in physics. The analysis suggested that practical activities in measurement in physics had a significant impact on student performance, as evidenced by the higher mean and standard deviation of the post-test scores (29.7, SD=7.2) compared to the pre-test scores (13.6, SD = 4.4), and the significant results of the paired sample t-test ($p = 0.010 < 0.05$, $t = 16.13 > 1.68$). Generally, the observations made during the post-laboratory test (Table 4.2) compared to the pre-laboratory test (Table 4.1) and opinions expressed by the students after the intervention showed an important effect of practical activities on students' process skills. The study recommended that measurement in physics should be treated with much attention at Kaleo Senior High and Technical School as it serves as the foundation to which all aspects of physics is built upon.

Keywords: piquing, grasp, subpar, conceptual, plausibility, abysmal, impeding.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the background to the study and the statement of the problem. It also throws light on the purpose of the study, research objectives, research questions, significance of the study, limitations, and delimitations of the study as well as the organisation of the study.

1.1 Background to the Study

According to Millar and Abrahams (2009), practical activity is any scientific teaching and learning activity that includes students at some stage, either alone or in small groups, observing or handling things to develop understanding. The importance of practical activity in teaching and learning at many different institutions cannot be disputed. It is a powerful strategy for increasing students' motivation and deepening their comprehension of scientific topics and concepts (Millar & Abrahams, 2009). To master the fundamentals of physics, students often memorise facts, ideas, laws, and other information that their teachers have taught (Khan et al., 2012). Researchers such as Abrahams and Millar (2009) and Nivalainen et al (2010) have suggested that the lack of practical activities is a crucial role, despite the fact that the findings of several research have identified a number of causes for science students' low conceptual understanding in developing nations. The role and advantages of practical activities in the physics curriculum include; motivating students and piquing their interest in the subject; assisting them in understanding the subject more thoroughly by connecting theory to practice and giving students the chance to collaborate on analysing and resolving scientific problems (Lee & Sulaiman, 2018).

Over the years, physics student performance in Ghana has typically and regularly been subpar (Anamuah-Mensah, 2007). According to performance statistics published by the West African Examination Council (WAEC) between 2018 and 2019, the WASSCE for School Candidates 2019 raw mean score of 27 out of 50 and a standard deviation of 07.92 with a candidature of 762340 indicates a low performance than that of WASSCE for School Candidates 2018, where a raw mean score of 28 out of 50 marks and a standard deviation of 07.62 with a candidature of 728924 was recorded. Majority of physics candidates did not receive the necessary pass grade (A-D or A1-C6) to be accepted to tertiary education (WAEC, 2019). This shows that the way science is taught in senior high schools does not correspond to how scientists work. It has been suggested that the situation could be improved by adopting a procedure where students identify problems, handle or manipulate objects, and conduct scientific experiments (Shana & Abulibdeh, 2020). This would bridge the large gap between the scientist and the processes through which science is taught in senior high school. Teachers, according to Van Driel et al. (2001), are the driving force behind improvements in educational outcomes and procedures. Learning outcomes are affected by the style of instruction since it significantly affects what is taught as well as how teaching and learning take place (Lingbiao & Watkins, 2001). According to Van Driel et al (2001) teachers' practical knowledge is composed of knowledge and belief systems that have a direct impact on their actual instruction and interactions with pupils. In order to effectively teach and understand secondary level physics, it is critical to take into account instructors' viewpoints on the importance of hands-on activities. There is a good chance that instructors' views have a significant impact on their actions (Bryan & Recesso, 2006).

As a result, the study focused on how practical activities such as reading measurements from instruments such as metre rule, vernier calliper, micrometre screw gauge, stop-clock etc as an intervention could help students at Kaleo Senior High Technical School improve their process skills, conceptual understanding, and performance in measurement in physics. Levin (2018) ascertained that knowing the fundamental truths and how they relate to one another is what is meant by conceptual knowledge. Giving students the chance to "battle" with difficulties and "explicitly" explaining conceptual linkages are two essential components of instructional techniques that support students in developing conceptual knowledge (Robinson et al., 2014). The capacity to apply one's knowledge and abilities in different circumstances is a talent that these methods aid students in developing. To explain phenomena, conceptual knowledge is necessary, making it a crucial aim in learning generally and a crucial goal in scientific education being able to interpret, comprehend, and explain are all necessary skills for understanding (Anderson et al., 2001). Understanding the principles governing a domain as well as the interrelationships between domain knowledge pieces is required (Rittle-Johnson et al., 2001). Promoting conceptual knowledge entails moving misunderstandings "toward more scientific ones" via a conceptual transformation process (Coştu et al., 2012). According to Ebenezer et al (2010), conceptual change is a process in which learners investigate their beliefs, become conscious within a learning community, compare them with scientific models and explanations for credibility, and then "refine, reconstruct, reconcile, or reject personal conceptions to align with the scientifically sound and agreed upon conceptions.

Finally, the purpose is to make students aware that "alternative competing concepts may be more fit for describing a reality" (Tan et al., 2020). That is, the structure of concepts as portrayed plays a significant role in the meanings that students construct and, as a result, the behaviours or functions that result from such understandings (Van Driel et al., 2001).

1.2 Statement of the Problem

Students from Form two science studying physics at Kaleo Senior High and Technical School (KASHTS) lack the skills and conceptual understanding in measurement in physics. It became evident when about 80% representing one hundred and seventy (170) students out of the entire physics student's population of two hundred and twelve (212) struggled to apply certain measuring skills and simple concepts in measurement during physics practical sessions. This led to most of the students showing abysmal performance during practical tests. Students' less exposure to some of these measuring instruments and inability to grasp meaning into what they have learned in measurement in physics were some factors impeding on their process skills, conceptual understanding and performance although the school has adequate laboratory equipment. Since practical activities are typically used to supplement the theories learned in class, the absence of practical activities has been one of the primary causes of students' conceptual difficulties in physics, according to Millar and Abrahams (2009) and Nivalainen et al (2010). The study sought to find out the effect of series of practical activities such as measuring the mass, length, breadth, height and diameter of solid objects using instruments such as metre rule, vernier calliper, micrometre screw gauge, stop-clock etc on senior high school students' process skills, conceptual understanding, and performance in measurement in physics.

1.3 Purpose of the Study

The purpose of the study was to determine the effect of practical activities on senior high school students' process skills, conceptual understanding and performance in measurement in physics.

1.4 Research Objectives

The objectives of the research were to:

1. Identify the process skills students are unable to perform under measurement in physics.
2. Determine the pre-conceptual process skills of students in measurement in physics.
3. Determine the effect of practical activities on students' conceptual understanding in measurement in physics.
4. Assess the effect of practical activities on student's performance in measurement in physics.

1.5 Research Questions

The following research questions were posed to find answers to the topic:

1. What process skills are students unable to perform under measurement in physics?
2. What are the pre-conceptual skills of students in measurement in physics?
3. What effect will the use of practical activities have on students' conceptual understanding in measurement in physics?
4. What effect will the use of practical activities have on students' performance in measurement in physics?

1.6 Research Hypothesis

H_0: There is no statistically significant difference between the performance of student's pre-test and post-test scores when exposed to practical activities in measurement in physics.

1.7 Significance of the Study

The findings of the study were anticipated to enhance students' process skills, conceptual understanding and performance in measurement in physics. Additionally, the students would acquire new physics techniques and be introduced to the advantages of adopting practical activities in learning. These techniques would encourage students to participate in practical activities.

Finally, the study would help the stakeholders in science (Physics) education and especially the National Council for Curriculum and Assessment (NACCA) to make an informed decision on whether to include practical activities in the syllabus to make the teaching and learning of physics effective.

1.8 Delimitation of the Study

The study covered only Kaleo Senior High and Technical School in the Nadowli/Kaleo District of the Upper West Region. Furthermore, because physics is a vast subject with various topics, this study focused on measurement in physics due to the time frame captured for the study and shortening of the academic calendar. Also, other extracurricular activities such as health talks, seminars etc. affected hours spent in the classroom during the Covid-19 pandemic.

1.9 Limitation of the Study

Academic researchers typically encounter difficulties from accomplishing their goals completely to which this study was not left out. Due to unscheduled time for practical activities, lack of funding, and unavailability of laboratory resources to cover the entire Senior High School physics students at large, the study was only limited to physics students at Kaleo Senior High and Technical School. Difficulty in access to the internet or library became a challenge at times which disrupted getting information from journals, books, and other study resources.

1.10 Definition of Terms

Piquing: To excite or cause interest.

Grasp: Ability to understand something.

Subpar: Below average, usual or normal level.

Conceptual: Related to ideas or principles.

Plausibility: An explanation or a statement that seems likely to be true or valid.

Abysmal: Exceptionally bad or displeasing.

Impeding: To slow something down or prevent an activity from happening.

1.11 Organisation of the Study

The study is organised into five chapters as follows;

The study is introduced generally in Chapter One. It explains the background to the study, the statement of the problem, the research objectives, the research questions, significance of the study, delimitations, limitations and definition of terms.

Chapter Two review relevant literature on the subject matter under consideration. Consequently, the chapter introduces the theoretical framework and conceptual framework of related literature adopted by the study. It also reflects on students process skills, conceptual understanding, strategies for conducting practical activities and the benefits of using practical activities as well as some empirical evidence based on the use of practical activities.

The research methodology and data sources are captured in Chapter three. The chapter also outlines the profile of the study area and sampling procedure which includes the population, sampling technique and sample size. The chapter also describes the data gathering procedure, tools used for data analyses, validity and reliability of instrumentation and finally presents the ethical issues considered.

The data collected are analysed and presented in Chapter Four. The chapter also addresses the findings about existing literature and evaluates the research questions.

Finally, chapter five presents the summary and findings of the study as well as conclusions and recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides an overview of previous research on the effect of practical activities on students' process skills, conceptual understanding, and performance. The following topics are discussed under this review; theoretical framework (the theory of constructivism), conceptual framework of the study, science process skills, students' conceptual understanding, students' academic performance in physics, strategies for conducting practical activities, the benefits of using practical activities in teaching and empirical evidence based on the use of practical activities.

2.1 Theoretical Framework

This study was based on the constructivist's theory of teaching and learning. Fernando and Marikar (2017) identified the constructivist approach to the learner's core ideas as; learning is an active construction of knowledge by the learner instead of passively absorbing information from the outside. Learning should be presented as a process of active discovery. The instructor's job in constructivist teaching is to guide students as they work to integrate new knowledge with prior knowledge and to change the prior knowledge to accommodate the new rather than to drill knowledge into them through constant repetition or to coerce them into learning through the use of carefully calculated rewards and punishments (Knauer, 2015).

2.2 The Conceptual Framework for the Study

The main aim of the study was to determine the effect of practical activities on students' process skills, conceptual understanding and performance in measurement in physics. Thus, it was expected that after students had been engaged in series of practical activities involving measurement, there would be a change in their process skills, conceptual understanding and performance. The arrows depict the flow and influence of one variable on another with specific relations to the research objectives guiding the study. Hence, students' process skills acquisition, conceptual understanding and improved performance in measurement are influenced by their exposure to series of practical activities. Engaging students in series of practical activities influence their process skills in measurement as well as teaching students some concepts in measurement promotes the level of their conceptual understanding in measurement in physics hence affects their performance positively. The framework depicted in Figure 2.1 provides a ground for the findings from the study to be measured.

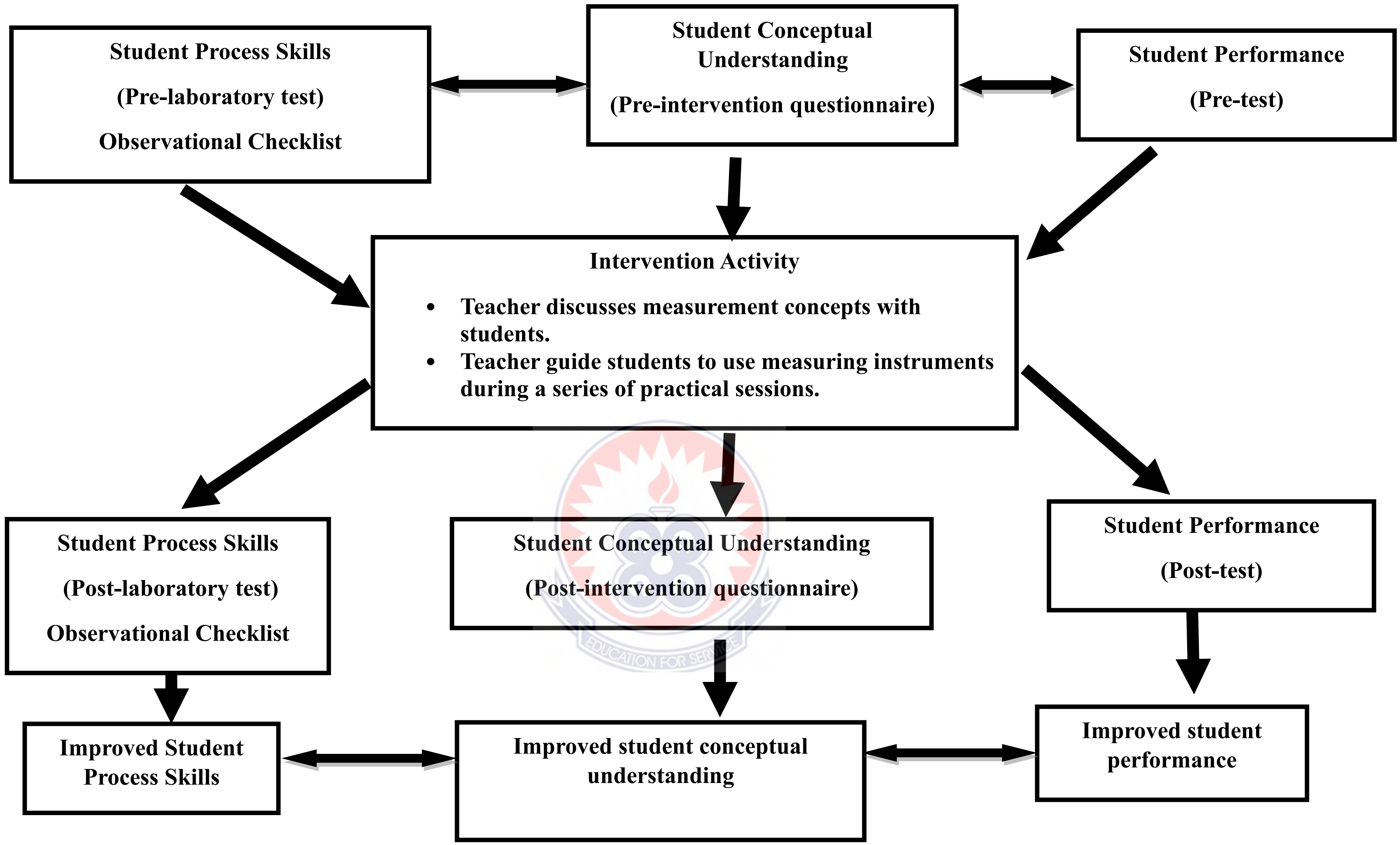

Figure 2.1: Conceptual Framework on using practical activities to improve students' process skills, conceptual understanding, and performance in measurement in physics.

2.3 Science Process Skills

According to Ratnasari et al (2018), Science process skills are abilities that support science learning, assist students in discovering successful research techniques, boost productivity, instil a feeling of responsibility in learners, and improve retention. In order to create knowledge, solve issues, and conduct experiments, scientists employ science process skills, which is a component of 21st-century thinking abilities (Okafor, 2018). The necessity to increase students' comprehension of science process skills through hands-on activities was outlined by Millar (2004). Basic process skills and integrated process skills are the two fundamental scientific process skills, according to Zeidan and Jayosi (2014). Basic science process skills include observation, inference, measurement, classification, and prediction. The integrated process skills entails developing operational definitions for variables, identifying and controlling variables, forming hypotheses, analysing data, and performing experiments (Zeidan & Jayosi, 2014). Higher order thinking skills known as integrated process skills are based on applying previously learned knowledge to new situations, analysing relationships between parts, identifying organizational principles, combining parts to form new wholes, and evaluating the suitability of a program to ensure that a conclusion is supported by evidence (Okafor, 2018).

Nopiya et al (2020) signifies that, science process skills are among the most important learning outcomes for science education programs as they are employed in both scientific investigations and the proper interpretation of everyday occurrences. It has been noted by Zainuddin et al (2020) that students' participation in science process skills serves as a foundation for the development of their comprehension of scientific ideas and concepts. According to Kalemku (2021), the increase in students' scientific achievement is mostly attributable to the growth of science process skills.

However, earlier and more current research have shown that the scientific process skills that students employ in one topic may be transferred to another field or profession (Bulent, 2015).

2.4 Conceptual Understanding

Platonists admit the existence of the word concept in the presence or absence of an observer, whereas naturalists contend that conceptions are created by the interaction of the mind with the outside world (Barsalou et al., 2003). According to Konicek-Moran and Keeley (2015), a concept is defined as a collection of meanings that share similarities, disparities, connections, and correlations observed. Konicek-Moran and Keeley (2015) denoted that students gain a deeper understanding of a concept when they apply it in a different situation, describe or define it in their own words, build a model of it, or find an appropriate metaphor for it. Sawyer (2008) stated that conceptual understanding entails applying an explanation to previously unknown novel situations. Kim and Chin (2011) also reported that, practical activities were an important tool for developing students' scientific knowledge and habits of mind, which agrees with the finding that practical work contributes to increased conceptual understanding ability. One essential part of conceptual understanding is its capacity to improve lesson retention.

2.5 Students' Academic Performance in Physics

From the perspective of many students, physics is challenging, and their performance in this subject is often subpar (Ornek et al., 2008). Even though studying physics might be difficult, it is crucial for everyone, including present and future generations as well as those who are interested in professions in science. Grover (2019) came to the conclusion that physics is essential for creating new things and refining ones we now rely on. The majority of the students struggle with science, and physics and chemistry in particular are challenging. Many students study a particular topic, like physics, because it is required as a part of the program they are enrolled in, rather than because they are interested in it. The study of physics is not very interesting to these kids (De Jong, 2010). Over the years, the senior high school's physics students have consistently performed poorly and in an appalling manner (Lacambra, 2016). Musasia et al (2016) remarked that the students poor achievement in the practical aspect of physics examination at the WASSCE level contribute to high failure rate of students in physics. According to performance statistics published by the West African Examination Council (WAEC) between 2018 and 2019, the WASSCE for School Candidates 2019 raw mean score of 27 out of 50 and a standard deviation of 07.92 with a candidature of 762340 indicates a low performance than that of WASSCE for School Candidates 2018, where a raw mean score of 28 out of 50 marks and a standard deviation of 07.62 with a candidature of 728924 was recorded. Majority of physics candidates did not receive the necessary pass grade (A-D or A1-C6) to be accepted to tertiary education (WAEC, 2019).

Antwi et al (2021) findings on students' participation in physics laboratory activities, teachers' attitudes toward physics as a subject, and the suitability of the lab's equipment for practical work are among the factors that affect students' academic achievement in practical physics. Several graduate and professional programs in science, technology, engineering, and mathematics require students to have a bachelor's degree in physics before they can apply. Despite this, the failure rate for this area of physics is notorably high. According to Duban et al. (2019), physics students' weak communication and observational abilities are a direct outcome of their lack of laboratory activities. Lack of these abilities led to students performing poorly on the practical portion of the general paper in physics. Hofstein and Lunetta (2004) found that students' interest in physics was generally higher when they participated in practical activities on a regular basis, but when the frequency decreased to the point where there were no laboratory activities for several weeks, the interest also decreased. Adequacy of the laboratory, a component of the educational environment, has been shown to have an impact on students' physics performance, according to Ural (2016).

2.6 Strategies for Conducting Practical Activities

Practical activities have been utilized in education for a wide range of objectives. It has been used to increase scientific knowledge and conceptual understanding in science instruction (Lunetta et al., 2007). However, the many goals that practical activities have been employed for have sparked spirited debates among scholars such as Hodson (1992) and Millar (2004). Growing educational technology has had a huge impact on science's dynamic nature throughout the past few decades. Researchers interested in the progress of teaching and learning have recently focused their study on practice-based education. In every educational setting, learning by doing is by far more effective for acquiring information and abilities. According to Zittleman (2006), prior work, interactive learning through inquiry processes has been shown to significantly boost learning in academic settings. Theories like progressivism, social reconstructionism, and existentialism, among others, emphasized developing one's own knowledge and abilities in order to educate one's mind, and these popular methods have since taken centre stage in educational systems. Learner-centred approaches have received a lot of attention in recent research in teaching and learning endeavours (Twahirwa & Twizeyimana, 2020). Teachers and instructors must put up a lot of effort to capture students' attention during class. According to research by Eddy et al. (2015), internalizing one's own knowledge and skills can increase learners' feeling of responsibility, which in turn can increase their engagement. Among the characteristics that affect learning sciences in contemporary education are practical works. Scientists, in particular instructors, might view practical activity as being fundamental to the goal and efficacy of scientific education. Niyitanga et al (2021) emphasized that acquiring science, technology, engineering, and math skills requires a foundation in practical work. This is because the quality of school scientific laboratories is of the highest significance. As previously established by Musasia et al (2016), studying sciences like physics mostly involves students engaging in practical. Practical activities offer opportunities for investigation, debate, think-pair-share, and problem-solving techniques to encourage learners' involvement in their learning process.

Agreeing to Abrahams and Millar (2008), practice-based learning is once in a while attempted by most instructors in undeveloped nations due to the shortage of assets, lacking down-to-earth aptitudes, huge course measures in auxiliary schools, and insufficient frameworks. In addition, the aforementioned factors largely determine how teachers approach teaching science via practice. When the instructor allows the student to freely develop their knowledge and skills, the student may need the instructor's assistance. At this point, the teacher-student contact becomes crucial. It is probable that learners will build their sense of creativity via observation, critical analysis, and curiosity, which in turn forms the basis of sound knowledge and abilities. According to the National Curriculum Framework for Science NCF (2005), the science curriculum should promote originality and innovation, and also, inquiry skills should be promoted and enhanced. Your children may learn about scientists' work and build their own investigation abilities through practical activities, especially through investigative approaches to science. Learning that is both "hands-on" and "minds-on" results from good practical exercises. Numerous practical activity plans exist, each with unique advantages and planning challenges such as:

- demonstration
- discovery learning
- context-based learning.
- Project-based learning

2.6.1 Demonstration

According to Ekeyi (2013), A demonstration is a type of instruction in which the teacher takes the lead and the students observe in order to participate later. Demonstration is the act of proving something by proof or evidence. It is clear from the term that the goal is to demonstrate and explain how something operates or is completed. Ekeyi (2013) emphasised that, demonstration approach involves the instructor modelling whatever it is that the student is supposed to research at the conclusion of the course. The instructor demonstrates to the class how to do the task and walks them through each step. Demonstration frequently takes place when learners find it difficult to relate theories to real-world situations or when they find it difficult to comprehend how theories are applied (Hussain, 2020). For instance, Basheer et al. (2017) explained that since demonstrations are less teacher-oriented and provide students the option to develop questions and become more active in the learning process, they increase student engagement. As a consequence, it may motivate students to carry out independent research and offer a teaching opportunity by encouraging linkages between previously taught content and new knowledge.

Ayimbila and Pappoe (2021) found that carefully crafted demonstrations can increase students' understanding of concepts. Similar to this, Hofstein and Lunetta (2004) came to the conclusion that demonstrations can enhance learning, motivation, and attitudes after conducting extensive evaluations. It could also affect students' academic performance In certain cases, teachers' demonstrations are also more successful than students' own experiments from an educational standpoint (Wong et al., 2013). The use of demonstrations in scientific instruction has been shown to have clear advantages in a number of study publications. Demonstrations increase generalization because they stimulate active student engagement, according to Buncick et al (2001) who conducted research on college introductory physics courses.

2.6.2 Discovery Learning

According to Yilmaz (2008), Constructivism's active process of generating context, justification, conversation, and tangible experiences is known as learning. Constructivist learning ideas underpin the discovery learning model of education. The experiences or knowledge that have been acquired are connected through a process called assimilation. In discovery learning, students are urged to find the concept rather than being provided it in its whole form. Based on the fresh knowledge and data sets they used to research learning, students construct knowledge (Hanafi, 2016). Students have a more lasting imprint of the material when they actively search for concepts throughout learning, which helps retain information longer. Students are encouraged to seek new information to increase their interest in learning through the process of examining the topics that are being taught (Munna & Kalam, 2021).

2.6.3 Context-based Learning

Context-based learning's objective is to guarantee that information acquired is relevant to and applicable to situations involving genuine challenges. It is a style of curriculum development and instruction that emphasizes practical exercises for students (Kumar Shah, 2020). Integrating real-world examples into classes and demonstrating how employing contexts may boost students' attention and understanding are both significant components of context-based learning (Bulte et al., 2006). Williams (2008) claimed that context-based learning is a method used that embeds student learning in practical settings and calls for the application of procedural knowledge. In other words, issue solving may be considered as a critical part of context-based learning that supports students in acquiring problem-solving abilities for real-world situations (Karan & Brown, 2022). In conclusion, context-based learning places a strong focus on developing students into competent real-world problem solvers by establishing student-centred learning settings that closely resemble real-world situations (Ali, 2019). To efficiently acquire and absorb knowledge, students must consider both the social context of the learning environment and the real context of what they are learning.

Students are given a scenario as part of the context-based learning process, and they participate in a series of hypotheses, actions, and assessments that provide student-centred learning (Trimmer et al., 2014). The phases of context-based learning should be unique, as suggested by Bahtaji (2021). The learner first engages in a practical experience or an interactive debate that combines old and new information. Secondly, through successful completion of learning activities, the learner conceptualizes the concepts and theoretical information drawn from one or more academic disciplines. Thirdly, the student applies theoretical and conceptual knowledge to practical problem-solving or knowledge application. Finally, a variety of approaches are used to generate and convey the data and conclusions.

2.6.4 Project-based Learning

According to Mergendoller et al (2006), project-based method is a teaching methodology that utilizes student-centered instruction to facilitate student learning. Project-based method can be described as student-centered instruction that occurs over an extended period of time during which students select, plan, investigate and produce a product, presentation or performance that answers a real-world question or responds to an authentic challenge (Agency, 2015). Teachers generally serve as facilitators, providing scaffolding, guidance and strategic instruction as the process unfolds.

Referring specifically to Lutz and Huitt (2004), all modern educators situate the project method within a constructivist-based theoretical framework. They regard students as active agents engaged in authentic tasks, solving real problems, and generating knowledge and skills in dynamic interaction with their physical and social environment, thus creating meaning of themselves and the surrounding world. The project method is one of the most effective methods of teaching science since it provides an excellent opportunity for students to think and afford the opportunity to study on their own (Zhylkybay et al., 2014). This implies that in project method the students have the chance to define problem, plan his or her own work, find appropriate resources to carry out his or her plan and at end draw a conclusion**,** they learn to train themselves for the task ahead of them in the future**.**

2.7 The Benefits of Using Practical Activities in Teaching

The practice-based teaching and learning approach is much better recognised as an effective strategy for imparting in students long-lasting information and abilities (Wegner et al., 2021). Because of the widespread use of technological tools, active research, and rapidly evolving lifestyles brought on by high societal demand, science educators have been forced to focus their lessons on practical work, enabling students to acquire skills that, of course, can be used in real-life situations. For instance, Musasia et al (2012) noted that practical activity in teaching and learning physics is accompanied by a number of benefits. Advantages of practical work include, but are not limited to, (1) teaching student's lifelong skills, (2) fostering self-learning, (3) fostering experiential learning, (4) uncovering realities not revealed in theories, (5) making it easier to put concepts into practice based on personal experience, etc. Due to their unmatched benefits in teaching and learning endeavours, practice-based teaching and learning approaches must be embraced and put into practice.

2.8 Empirical Evidence Based on the Use of Practical Activities

For the practical activity-based technique to be justified as a superior teaching strategy for physics education, researchers and educators present a variety of supporting data. According to Anwar (2019), the practical activity-based approach encourages in-depth, interdisciplinary, teamwork learning, gives students ownership over their education, and makes learning relevant and engaging. This method enables teachers to incorporate learning into students' existing knowledge while also exposing them to a variety of learning opportunities. Students benefit from the development of skills such as teamwork, communication, design leadership, project management, research-problem solving, reflection, and lifelong learning through these activities. According to Molloy et al (2020), active participation in learning activities encourages students to seek out additional knowledge and helps them develop conceptual understanding. Hake (1998) discovered that students' conceptual knowledge in the Physics class is greatly improved by practical activity-based learning. Tremblay (2013) came to the conclusion that classes receiving practical activity-based learning performed much more accurately on the exam and displayed higher attitudes than classes receiving instruction using the conventional way. In medical education, the value of activity-based learning in promoting self-directed learning and problem-solving abilities is well established (Barrett, 2016). Regarding the psychology of memory, research also shows that active engagement and learning by doing are the most crucial elements to raise students' accomplishment and retention levels (Hyland, 2002).

A well-organised practical assignment can boost students' motivation and sense of ownership over their education, according to Lunetta et al (2007). They said that there is strong support for the idea that laboratory work, when thoughtfully designed, well-prepared, successfully taught, and followed up, provides students with opportunity to advance their knowledge and abilities in ways that enrich their regular classroom experiences. According to Luketic and Dolan (2013), practical activities encourage favourable attitudes and interest in science. Work that requires practical application offers motivating advantages like interest and satisfaction, skill development, science information acquisition, understanding of the scientific method, and scientific thinking. Therefore, further research into how practical work affects students' academic achievement is valuable.

2.9 Measurement in Physics

Measurement is a fundamental concept in physics, as it is through measurements that we gain a deeper understanding of the physical world. In this literature review, we will discuss some of the important aspects of measurement in physics. One of the most important aspects of measurement in physics is the concept of precision. According to Taylor (1997), precision is the degree of agreement between a set of measurements of the same quantity. The more precise the measurements are, the closer they will be to each other. This is important in physics, as it allows us to reduce errors in our measurements and obtain more accurate results. Another important aspect of measurement in physics is the concept of accuracy. According to Resnick and Halliday (2014), accuracy is the degree of agreement between a measurement and the true value of the quantity being measured. Accuracy is also crucial in physics, as it allows us to obtain reliable results that can be used to make predictions and test hypotheses.

In addition to precision and accuracy, another important aspect of measurement in physics is the concept of uncertainty. According to Bevington and Robinson (2003), uncertainty is the degree of doubt that exists about the result of a measurement. Uncertainty is often represented by an error bar on a graph or a plus/minus value associated with a measurement. It is important to take into account the uncertainty of measurements, as it allows us to determine the level of confidence we can have in our results. When it comes to measuring physical quantities, there are a variety of different techniques that can be used. For example, in their book "Experimental Techniques in Low-Temperature Physics", White and Meeson (1999) discuss various measurement techniques used in low-temperature physics, such as calorimetry, thermometry, and magnetometry. Each technique has its own advantages and disadvantages, and the choice of technique will depend on the specific physical quantity being measured.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the methodology used to conduct the study. It includes the research design, population and sampling procedures, research instruments, validity and reliability of research instruments, data collection and data analysis procedures.

3.1 Profile of the Study Area

Nadowli-Kaleo District is centrally located in the Upper West Region of Ghana. It lies between latitude 11' 30' and 10' 20' north and longitude 3' 10' and 2'10' west. It shares borders with Wa Municipal to the south, Burkina Faso to the West, Jirapa District to the north and Daffiama-Bussie-Issa District to the east. It covers a total land area of 2,742.50km^2 and extends from the Billi Bridge (40km from Wa) to the Dapuori Bridge (almost 12km from Jirapa) on the main Wa – Jirapa-Hamile road and also from West to east it extends and bordered by Daffiama-Bussie-Issa District (Ghana Statistical Service, 2014).

The location of the district promotes international trade between the district and neighbouring Burkina Faso. However, the District faces the threat of low attendance and retention in schools due to prevailing diseases and its location so active measures must be taken to deal with these threats. The district has a heterogeneous population. The major tribe is the Mole-Dagbani (88.3%). Other tribal groups are the Grusi, Ewes Guan etc representing 1.7% 1.2% and 1.1% respectively of the population of the district. Settlement creation in the district is largely on ad hoc basis and usually near and around arable lands and water bodies. It also has scattered communities dotted all over the district (Ghana Statistical Service, 2014).

From the 2021 Population and Housing Census report, the Nadowli-Kaleo District has an estimated population of about 77,057 distributed among 81 communities. Out of the total population, female population was about 40,064 representing about 52% of the total population. The male population on the other was about 36,993 representing about 48% of the total population. Comparably, it is evident that the Female population of the district out-weighs the population of the male. The district has five senior high schools namely, Queen of Peace Senior High School, St. Basilides Senior High and Technical School, Kaleo Senior High and Technical School, Takpo Senior High School and the newly established Sombo Senior High School. All the secondary schools in the catchment area are boarding and are also mixed in the terms of sex structure. In the study area only one teacher training college (McCoys College of Education) is present and vibrant in terms of academic performance. The training college is also boarding and mixed.

3.2 Research Design

A research design is defined as "the techniques used in research projects for collecting, analysing, interpreting, and reporting data"(Yu, 2009). The overall strategy for bridging the gap between relevant (and doable) empirical research and conceptual research challenges. In other words, the study design determines how to collect the necessary data, what techniques will be used to analyse the data, and how all of this information will be used to answer the research question (Boru, 2018). Research design, which is the core of every study, is defined by Kothari (2004) as a strategy, a plan, and a road map for investigation that were created to find answers to research questions.

In this study, an action research design was used. Action research is a systematic inquiry-method that examines a school environment in order to comprehend and enhance the quality of the educational process (Hine, 2013). Action research, according to Smith (2010), is a method in which a practitioner conducts a scientific study of an issue before making judgments, evaluating, and improving it. Since there is always space for improvement when it comes to instructing and educating others, action research is highly well-liked in the field of education, claimed by Lykes and Scheib (2017).

There are many different ways to educate in the classroom, but action research excels because the cycle allows for ongoing reflection. The aim of action research is to enhance procedures in all professional sectors. Action research is helpful in contexts where ongoing improvement is a priority, particularly in teaching and learning, or in areas of teaching practice that need to be investigated. This design was appropriate to help determine the effect of practical activities on students' process skills, conceptual understanding and performance on measurement in physics. The problem was confirmed by the pre-intervention activities, and the effectiveness and impact of the intervention were assessed through post-intervention activities.

3.3 Population

According to Djamba and Neuman (2002), a population is a collection of all the units that the research includes or may be applied to. The population is the group to which the researcher wishes to generalise the study's findings. All people who possess specific defined traits are included. To put it another way, population refers to the bigger group to whom a researcher would want to extrapolate the findings of a study (Zohrabi, 2013). Target population and accessible population are the two components of population. The group that the researcher is interested in is known as the target population. It is this group that the researcher could generalize the study findings (Zohrabi, 2013). The Researcher focused on all students offering physics at Kaleo Senior High and Technical School in the Nadowli-Kaleo district in the Upper

West region of Ghana. The target population covers the entire form two science students and technical students studying physics at Kaleo Senior High and Technical School. The population consisted of two hundred and twelve (212) students of which Form three had sixty-five (65) students, Form two had forty-nine (49) students and Form one had ninety-eight (98) students.

3.4 Sampling Technique and Sample Size

Ary et al. (2010) defined a sample as a portion of a population, or a group selected from a population for observation in a study. There are several sampling techniques including random sample, stratified sample, quota sample, purposive sample and convenience sample. Sampling, according to Turner (2022) is the process of selecting elements or individuals from a population to represent the attributes of that population. The goal of sampling is to collect a group of people who will be representative of the larger population or will provide specific information. The sample technique used determines the degree of representativeness. The two main types of samples are probability and non-probability sample. Probability sample is the type where every member of the population has equal opportunity to be selected into the sample. The kinds of probability samples are as follows: simple random, systematic, stratified random, cluster, multistage and multiphase sampling. Non-probability sampling occurs when some members of the population have no chance of being chosen. The kinds of non-probability samples are purposive, quota and convenience.

Etikan (2016) defined purposive sample as the type in which the Researcher handpicked the students to be included in the sample on the basis of their judgment of their typicality. Purposive sampling involves the researcher selecting respondents who are knowledgeable about the topic of interest (Tongco, 2007). According to Campbell et al (2020), purposive sampling is the selection of sample on the basis of the judgment of the researcher. When it comes to picking the units to be researched, such as persons, cases, organisations, events, or pieces of data, purposeful sampling relies on the researcher's judgement. In this study, the researcher chose an intact class of a total sample size of forty-nine (49) physics students in Form two. These forty-nine students (49) were made up of sixteen (16) students from Form two science, thirteen (13) students from Form two Technical 1, eleven (11) students from Form two Technical 2 and nine (9) students from Form two Technical 3. These intact classes were used for the study since they lacked some measurable skills and conceptual understanding in measurement in physics. Also, they have already spent a little more than a year at school and have been introduced to some basic scientific process abilities. They had also learnt some fundamental principles in Physics (especially in measurement).

3.5 Data Collection Instrument

The researcher used observational checklist, questionnaires and tests as instruments for the collection of data. A description of each of these instruments are as follows.

3.5.1 Observation Checklist

One of the earliest and most essential techniques to qualitative research methodology is observation. This strategy entails methodical and relevant data collection utilizing one's senses, particularly gazing and hearing (McKechnie, 2008). Meanwhile, Fraenkel and Wellen (2012) distinguish three types of observation: participant observation, nonparticipant observation, and naturalistic observation. Participant observation is an observation in which the observer takes part in the scenario or location being observed. In non-participant observation, the observer does not take part in the action being watched and is not directly involved in the scenario being seen. Then, naturalistic observation entails observing people in their natural environment. Therefore, non-participant observation was taken by the researcher to identify the process skills students are unable to perform in measurement in physics during a laboratory test. The researcher grouped the selected students for the study into ten (10) groups with each group consisting of about five members at the science laboratory. The researcher went round and observed each group whilst they performed a laboratory test as shown in APPENDIX B. During the observation, the researcher used observation checklist indicated in APPENDIX A as an instrument to collect data on their process skills in measurement in physics. An observation checklist is a list of items that an observer will look at while watching a class. This checklist was prepared by the observer (researcher) and his supervisor. Observation checklists does not only provide an observer with a structure and framework for an observation, but they also function as a contract of understanding with the instructor, who may feel more at ease and get specific comments on areas of the class as a consequence.

3.5.2 Questionnaire

According to Artino et al (2014), a questionnaire is a research instrument consisting of series of questions for the purpose of a survey or statistical study. The questionnaire was designed to reflect lessons drawn from the literature review. It also integrates the central themes of the research questions and the project objectives. The questionnaire consisted of nine (9) close-ended and ten (10) open-ended items. It was divided into three sections which were as follows: Section A sought information on demographic characteristics of respondents and Section B involved closed ended items on a five-point Likert scale rated in the range Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) and Strongly Agree (5) which sought information on the pre-conceptual skills of students in measurement in physics. Section C contained open ended items which sought information on students' conceptual understanding in measurement in physics. A sample of the questionnaire is shown in APPENDIX C.

3.5.3 Test

According to Hayati (2020) as quoted by Anas Sudjiono defined test as an instrument or a systematic technique for observing and characterising one or more qualities of a student using a nominal system or a set of criteria. In this study, achievement test was one of the instruments used. The acievement test comprised two test namely pre-test and post-test. This was done to assess students' performance and the effectiveness of the representation lessons after successful treatment of the selected topics. The scripts were marked and scored and immediate feedback was given to the students. An intervention procedure was designed for implementation to ascertain its effectiveness on students' performance. A pre-test and post-test indicated in APPENDIX D were designed to measure their performance before and after the intervention phase.

3.6 Validity of the Instrument

Validity of an item refers to the extent to which an item measures what it is supposed to measure (Denzin & Lincoln, 2001). The goal of a good research is to have results that are reliable and valid (Creswell, 2005). Validity is concerned with whether the findings are really about what they appear to be about (Robson, 2002). Bashir et al (2008) noted that validity remains important within any research that needs to ensure that people's lives, experiences, and views are represented accurately.

The instruments were also evaluated utilising expect judgement through content validity. The degree to which the sample of items represents the content that it is supposed to measure is referred to as content validity (Orodho, 2009). The researcher evaluated content validity by utilising specialists in the field of scientific (Physics) education. The Researcher also discussed with his supervisor, other lecturers and colleagues on whether the instruments accurately represented the concept of the study. Their ideas were well considered and appropriately incorporated.

3.7 Reliability of the Instrument

According to Drost (2011), reliability is "the extent to which measurements are repeatable when different people perform the measurement on different occasion, under different condition, supposedly with alternative instruments which measure the construct or skill". There are many distinct dimensions to reliability of which checking for internal consistency is one of the features. Internal consistency refers to the degree to which items that makes up a scale "hang together" or measure the same underlining construct (Hajjar, 2018). To ensure reliability, test reliability was ensured by pilot testing the instrument (questionnaire) with physics students of Queen of Peace Senior High School at Nadowli in the Upper West region. Selected physics students answered the questions and based on the responses, a Cronbach Alpha value of 0.960 was obtained, indicating an acceptable level on reliability with high correlation. A copy of the calculated Cronbach Alpha value by statistical package for social science (SPSS) version 26 is indicated in APPENDIX F.

3.8 Ethical Considerations

Before data was collected, an introductory letter was given by the university to prove that the research was legitimate and was known by the university. The introductory letter included the details of the Researcher, the name of the university that the Researcher attends, the name of the supervisor and the reason for doing the research at their school among others. The introductory letter also indicated that the participants would remain anonymous and that their responses would be kept confidential.

The Researcher took consent from the school heads and teachers before administering the questionnaires to them. Participants were made aware that, their participation was voluntary. Participants were assured of the confidentiality of their responses. They were made aware that, the information they provided was not going to be made public, and none of respondents' name, addresses, date of birth and any possible means by which their identity will be made public was requested. All references were duly acknowledged to avoid plagiarism.

3.9 Data Collection Procedures

This study involved pre-intervention phase, intervention phase and post-intervention phase.

3.9.1 Phase 1: Pre-Intervention Phase

At the first phase of the pre-intervention, students were allowed to demonstrate some process skills by measuring physical quantities with various measuring instruments through an organised pre-laboratory test (APPENDIX B). The students process skills during the hands-on activity was then evaluated using an observation checklist (APPENDIX A). This evaluation was done by grouping of students into ten (10) with each group comprising of about five (5) students and were being observed accordingly. A pre-intervention questionnaire (APPENDIX C) was carried out by each student in each group to determine their pre-conceptual skills and level of conceptual understanding in measurement in physics. Also, a general pre-test (APPENDIX D) was conducted before the intervention to ascertain their performance in measurement in physics.

3.9.2 Phase 2: Intervention Phase

At the second phase, the researcher taught some selected topics and organised series of practical activities in measurement in physics for three weeks focusing on improving student's process skills, conceptual understanding and performance. The first week of the intervention phase comprised with teaching concepts related to measurement in physics. The second and third phase imbued with laboratory practical exercises and hangs-on activities on how to use some measuring instruments in measurement using group work. Students were guided to perform laboratory practical experiments both in groups and on their own. The practical exercises were constructed based on the concepts and process skills developed within the week, and each lasted 90 minutes. A progressive test was carried out after each lesson where responses were marked and distributed to students before the next lesson. This evaluation was done to enable students identify specific strengths and areas needed for improvement. General discussion on the feedbacks was done after the distribution of the marked scripts. Weakness and misrepresentation on the concepts and process skills were addressed. A sample of the rubrics for the lesson plan which was used for all the weekly lessons are as follows:

Lesson Plan

Week One

Introduction

Dear students, you are welcome. This lesson introduces you to the study of Measurement in Physics.

Learning objectives

By the end of this lesson, the student will be able to:

- Explain scientific units and measurement.
- Distinguish between accuracy and precision.
- Explain least count and error analysis.
- Measure the time

Activity

Teacher brainstorms students to come out with their definition of measurement and state some scientific units.

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Content

Measurement

Measurement is a technique for determining an object's qualities by comparing it to a particular quantity. A measurement can also be a unit or system to calculate a standard measure by finding out the size, weight, force, or amount of something. The International System abbreviated as SI units are described as standard units. A standard unit is a unit of measurement that is understood and accepted by people all over the world. Standard units can be categorised into basic and derived units.

Basic Unit

A basic unit is a fundamental unit from which all derived units can be obtained. The seven fundamental quantities and their units are presented in Table 3.1

Table 3.1: Seven fundamental quantities and their units

Quantity	SI unit	Symbol
Length	**Metre**	**M**
Mass	**Kilogram**	**Kg**
Time	**Second**	**S**
Electric current	**Ampere**	**A**
Temperature	**Kelvin**	**K**
Luminous intensity	**Candela**	**Cd**
Amount substance	**Mole**	**Mol**

Derived Unit

A derived unit in the SI system is a combination of two or more base or fundamental units. Examples are as shown in Table 3.2:

Table 3.2: Derived unit in the S.I system.

Quantity	SI unit	Symbol
Force	**Newton**	**N**
Work and Energy	**Joule**	**J**
Power	**Watt**	**W**
Quantity of electricity	**Coulomb**	**C**
Electric potential	**Volt**	**V**
Electric resistance	**Ohm**	**Ω**

Precision and Accuracy

There are two main types of errors associated with an experimental result. They are referred to as precision and accuracy. The precision is usually related to the random error distribution associated with a particular experiment or even with a particular type of experiment (for example, in experiments where the measured parameters have intrinsically large variations between different samples). The accuracy is related to the existence of systematic errors, for example, incorrect calibration. The object of a good experiment is to improve both precision and accuracy. Usually in a given experiment one of these two types of errors is dominant, and the scientist devotes most of his or her efforts towards reducing that one. For example, if you are measuring the length of a carrot in a sample of carrots to determine an average value of the length, the natural random variations within the sample of plants are probably going to be much larger than any possible measurement inaccuracy due to a bad manufacturing of the ruler that you use. In a physics laboratory, the relative effects of the precision and accuracy on the final result usually depend on the particular experiment and the particular apparatus. Some experiments in the introductory physics laboratory have relatively large random errors that require repeating measurement to increase the precision.

Least Count

Least count for a measuring instrument means the smallest value that can be measured using the instrument. This can be calculated by dividing the maximum value that can be measured using the instrument by total number of divisions on the scale. Least count gives the resolution of the instrument. The least count error is the error associated with the resolution of the instrument. The least count error occurs with both systematic and random errors. Instruments of higher precision can reduce the least count error. By repeating the observations and taking the arithmetic mean of the result, the mean value would be very close to the true value of the measured quantity.

Sources of Error

- **Reading Error:** Almost all direct measurements involve reading a scale (ruler, calliper, stopwatch, analogue voltmeter, etc.) or a digital display (e.g., digital multi-meter or digital clock). Sources of uncertainty depend on the equipment we use. One of the unavoidable sources of errors is a reading error. Reading Error refers to the uncertainties caused by the limitations of our measuring equipment and/or our own limitations at the time of measurement (for example, our reaction time while starting or stopping a stopwatch). This does not refer to any mistakes you may make while taking the measurements. Rather it refers to the uncertainty inherent to the instrument and your own ability to minimise this uncertainty. A reading error affects the precision of the experiment. It is usually difficult or impossible to reduce the inherent reading error in an instrument. In some cases (usually those in which the reading error of the instrument approximates a "random error distribution"), it is possible to reduce the reading error by repeating measurements of exactly the same quantity and averaging them.
- **Random Error**: it refers to the spread in the values of a physical quantity from one measurement of the quantity to the next, caused by random fluctuations in the measured value. For example, in repeating measurements of the time taken for a ball to fall through a given height, the varying initial conditions, random fluctuations in air motion, the variation of your reaction time in starting and stopping a watch, etc., will lead to a significant spread in the times obtained. This type of error also affects the precision of the experiment.

- **Systematic Error** refers to an error which is present for every measurement of a given quantity; it may be caused by a bias on the part of the experimenter, a mis-calibrated or even faulty measuring instrument. Systematic errors affect the accuracy of the experiment.
- **Zero Error:** It is a type of error in which an instrument gives a reading when the true reading at that time is zero. For example, the needle of ammeter failing to return to zero when no current flows through it.

Significant Figures

Significant figures are the digits of a number that are meaningful in terms of accuracy or precision. They include:

- All non-zero digits are significant. 198745 contains six significant digits.
- All zeros that occur between any two non-zero digits are significant. For example, 108.0097 contains seven significant digits.
- All zeros that are on the right of a decimal point and also to the left of a non-zero digit is never significant. For example, 0.00798 contained three significant digits.
- All zeros that are on the right of a decimal point are significant, only if, a non-zero digit does not follow them. For example, 20.00 contains four significant digits.
- All the zeros that are on the right of the last non-zero digit, after the decimal point, are significant. For example, 0.0079800 contains five significant digits.
- All the zeros that are on the right of the last non-zero digit are significant if they come from a measurement. For example, 1090 m contains four significant digits.

An uncertainty should not be stated with too much precision. The last significant figure in any stated answer should usually be of the same order of magnitude (in the same decimal position) as the uncertainty. For example, the answer 92.81 s with an uncertainty of 0.3 s should be rounded as (92.8 ± 0.3) s. If the uncertainty is 3 s, then the result is reported as (93 ± 3) s. However, the number of significant figures used in the calculation of the uncertainty should generally be kept with one more significant figure than the appropriate number of significant figures in order to reduce the inaccuracies introduced by rounding off numbers. After the calculations, the final answer should be rounded off to remove this extra figure.

Measurement of Time

Time provides us with a measure of change by putting dates on moments, fixing the durations of events, and specifying which events happen before which other events. In order to do that, some method of time measurement is needed. The science or art of the accurate measurement of time is known as **chronometry** (timekeeping). A similar concept, horology, usually refers to mechanical timekeeping devices or timepieces. Time can be measured both in terms of the absolute moment when a particular event occurs, or in terms of a time interval, that is the duration of a continued event. There are two main methods used in the everyday measurement of time, depending on the accuracy required or the interval covered. A clock is a physical mechanism that counts the ongoing passage of time, and is mainly used for more accurate timekeeping and for periods of less than a day. A calendar is a mathematical abstraction used for calculating more extensive periods of time (longer than a day). Typically, both methods are used together to specify when in time a particular event occurs, example 12:30PM on 16 December 2013. Even before such methods were devised, mankind has always used more informal methods for basic timekeeping, such as the cycle of the seasons, and of day and night, and the position of the Sun in the sky.

Scientific Unit of Time

The common and widely used units include minute, hour, day, week, month and year. If we are considering long durations of time, multiples of years are also used to mark a certain time frame. It can be, a decade which is equal to 10 years, a century which is equal to 100 years, a millennium which equals to 1,000 years, and mega-annum which is about 1,000,000 years.

Table 3.3: Units of Time

Units of Time	
Minute	60 seconds
Hour	60 minutes, or 3,600 seconds
Day	24 hours, or 86,400 seconds
Week	7 days, or 604,800 seconds
Month	28-31 days, or 2,419,200-2,678.400 seconds
Year	365.25 days, or about 31,557,600 seconds

How to Measure Time Using an Analogue Clock

Figure 3.1: A picture of an analogue clock

Measurement of time is read by a clock or a watch. Any clock or watch except a digital watch, has a dial. On the circular border of the dial of a watch or clock there are the hour numbers from 1 to 12 at equal intervals. Between the two numbers there are five divisions. Each division represents a minute. There are two hands of different lengths having one of the ends fixed at the centre of the dial. The small hand is the hour hand and longer hand is the minute hand. The hour-hand moves slower than the minute hand. There is also a third hand called the second-hand. It moves very fast. The hour hand makes one round of the dial in 12 hours. It moves from one number to its nearest number in one hour. The minute hand makes one round of the dial in 1 hour. It moves across one division in one minute. If there is a second-hand, it makes one round of the dial in one minute, that is it moves across one division in one second.

Progressive Test

1. What is measurement? 1mrk

2. Differentiate between precision and accuracy. 3mrks

3. Explain what is meant by least count of a measuring device. 3mrks

4. State the seven (7) basic quantities and their units. 7mrks

5. State and explain three types of error in measurement. 6mrks

Week Two

Introduction

Dear students, you are welcome. This lesson introduces you to Measurement of length.

Learning objectives

By the end of this lesson, the student will be able to:

- Define length.
- Demonstrate how to measure length using tape measure, micrometre screw gauge and vernier calliper.

Activity

Student engages in hands-on activity at the laboratory using tape measure, micrometre screw gauge and vernier calliper.

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Content

Measurement of Length

Length is the term used for identifying the size of an object or distance from one point to another. Length is a measure of how long an object is or the distance between two points. The length of an object is its extended dimension, that is, its longest side**.** Measuring length means measurement of the length of any object with the help of measuring tools like a ruler, measuring tape, vernier calliper, micrometre screw gauge etc. For example, the length of a pencil can be measured in inches using a ruler. The height of students in a class can be measured in feet using a measuring tape. The standard unit of length based on the metric system is a meter (m). According to the length that needs to be measured, we can convert a meter into various units like millimetres (mm), centimetre (cm), and kilometre (km). Centimetres and millimetres help measure smaller lengths and meters and kilometres help measure larger lengths like distance. For example, the length of the pencils can be calculated in centimetres (cm), while kilometres can measure the distance between two

buildings or places.

How to Measure Length Using a Tape Measure

Figure 3.2: A picture of a tape measure

A tape measure, or measuring tape is a type of hand tool typically used to measure distance or size. It is like a much longer flexible ruler consisting of a case, thumb lock, blade/tape, hook, and sometimes a belt clip. A tape measure will have imperial readings, metric readings or both. Metric measurements on a measuring tape are displayed in millimetres, centimetres and metres whereas Imperial measurements are in feet, inches and fractions of inches. Tape measures are common measuring tool used in both professional trades and simply around the home.

- **Catch the hooked end on one side of the object you are measuring**. If you are using a retractable tape measure note that the end of the tape will almost always have a small metal notch at the zero mark. This is useful for holding the tape in the right place as you measure, so you may want to start by catching it on the edge of the object you're measuring.
- **Stretch the tape across your object.** With the zero mark in place, pull back on the box to let more tape out. You can use one hand (or a friend) to hold the end of the tape in place as you pull it back. Let tape out until it stretches all the way across the distance you're measuring.
- **Take a reading directly from the tape.**
- **Use the lock switch to keep the tape at the same length.** Most retractable tape measures will have a button or sliding switch that, when pressed, keeps the tape measure from being sucked back in.

How to Measure Length using a Micrometre Screw Gauge

A micrometre screw gauge is a device widely used in the mechanical engineering field for measuring extremely small dimensions. A micrometre screw gauge has two scales: the main scale and the vernier scale. The main scale of a micrometre is calibrated in millimetres. The calibrations of the main scale of micrometre screw gauge vary depending on the range of measurement that the micrometre screw gauges are meant to measure. The vernier scale has 50 equal divisions. Each division is obtained by dividing 5 by 10. The vernier scale move a distance of 0.5mm along the main scale when it make 1 revolution by turning round once. One division on the vernier scale equal to 0.5/50 which equal to 0.01mm on the main scale.

Figure 3.3: A picture of a micrometre screw gauge

- Open the micrometre by turning the thimble or ratchet.
- Place the object to be measured between the spindle and anvil.
- Close the spindle by turning the ratchet, not the thimble. The ratchet prevents excess pressure on the object being measured, so you don't squash it and get a false reading.

- Now read the scale:

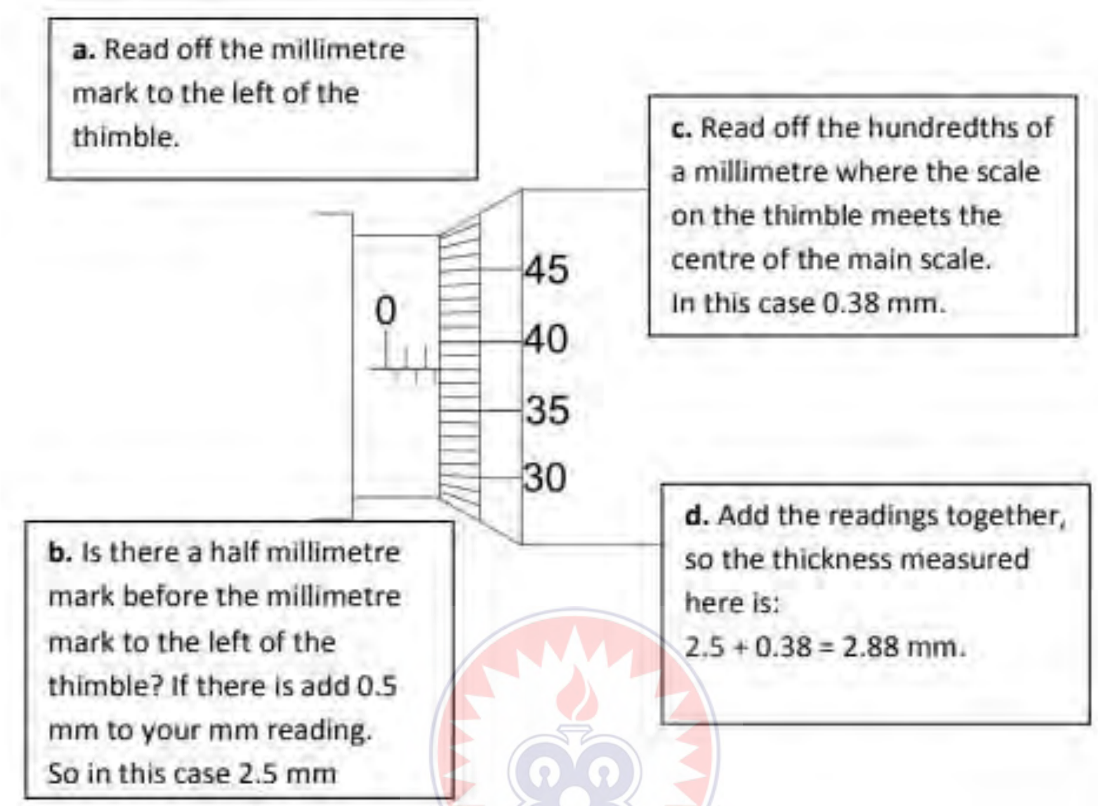

Figure 3.4: Diagrammatic representation of taking reading from a micrometre screw gauge

How to Measure Length Using a Vernier Calliper

Vernier callipers are measuring tools used mainly for measuring linear dimensions. These callipers come handy in measuring the diameter of circular objects. Their circular jaws fit securely on either side of the circumference of round objects. Vernier callipers have two types of scales- a fixed main scale and a moving Vernier scale. The main scale is normally in millimetres or 1/10th of an inch. Vernier callipers score well over standard rulers because they can measure precise readings up to 0.001 inches.

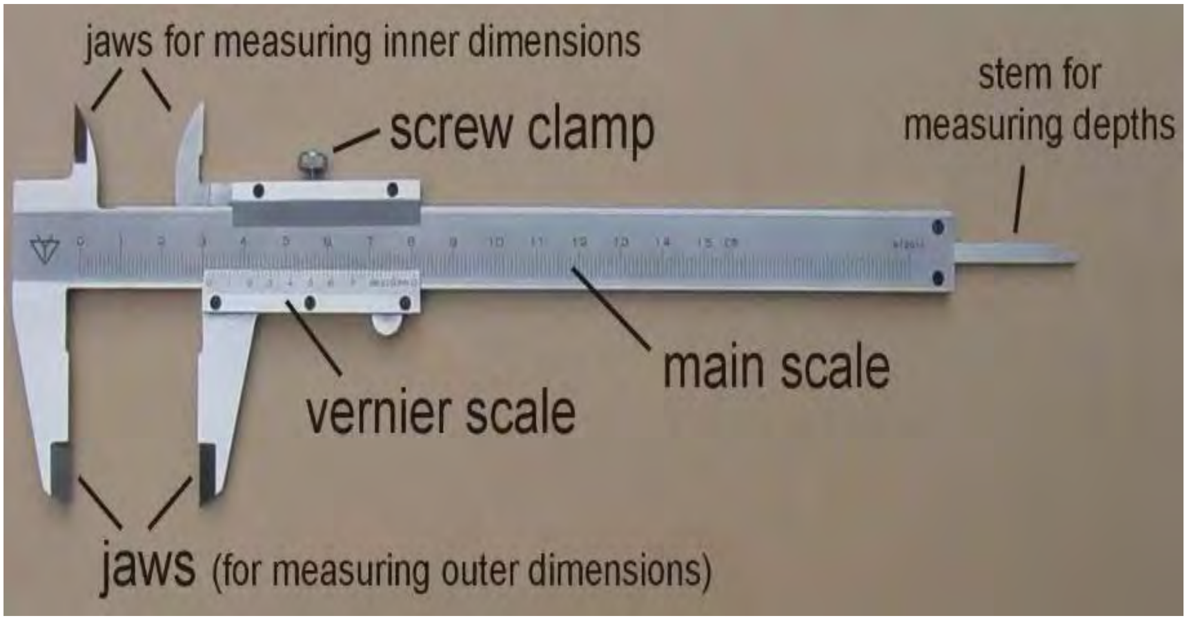

Figure 3.5: A picture of a vernier calliper

- Unlock the lock screw and press the thumb screw down. Open the jaws.
- Close the jaws around the object you want to measure or, for inside measurements open them until the fill the gap you wish to measure, or insert the depth rod into the hole you wish to measure.
- Tighten the lock screw so that the jaws do not move.
- Now read the scale.

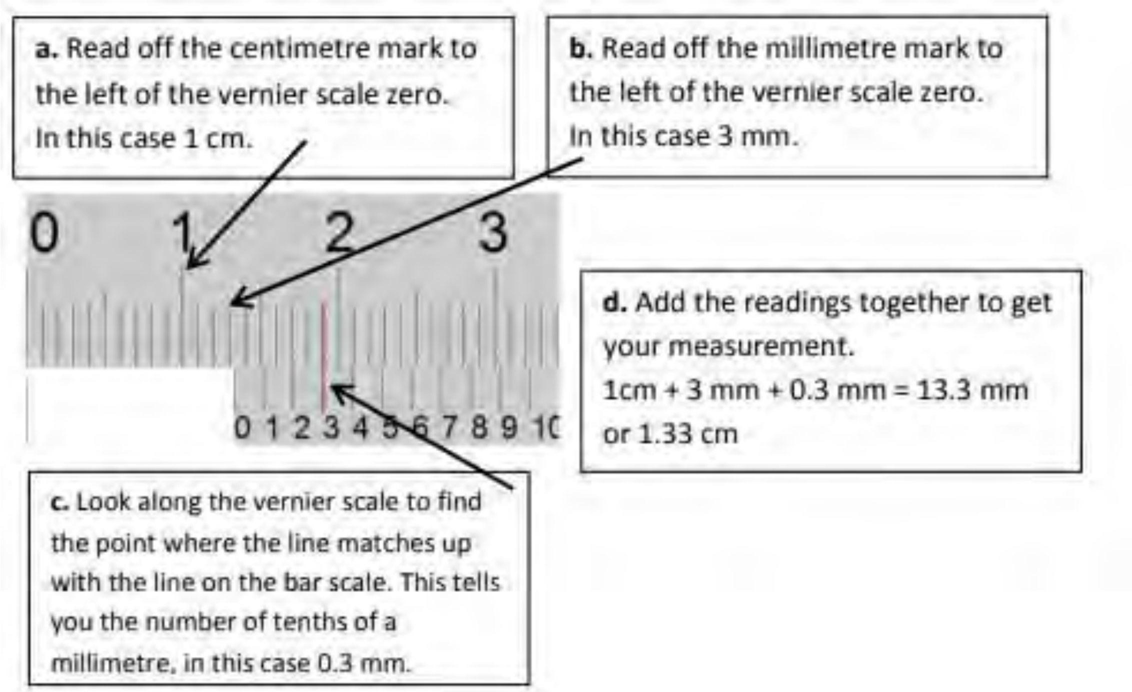

Figure 3.6: Diagrammatic representation on how to take readings from a vernier calliper

Progressive Test

1. What is length in terms of measurement. 2mrks
2. Give three (3) measuring tools used in measuring length. 3mrks
3. Write down the least count of a vernier calliper and micrometre screw gauge 2mrks
4. Explain how to take reading using a tape measure. 3mrks
5. How is reading on the main scale of a micrometre taken. 5mrks
6. Explain how the vernier scale is used in taking readings from the vernier calliper. 5mrks

Week Three

Introduction

Dear students, you are welcome. This lesson introduces you to Measurement of mass.

Learning objectives

By the end of this lesson, the student will be able to:

- Define mass and weight.
- Demonstrate how to measure mass using triple beam balance, spring balance and electronic balance.

Activity

Student engages in hands-on activity at the laboratory using triple beam balance, spring balance and electronic balance.

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Content

Measurement of Mass and Weight

Mass is the quantity of matter in a physical body. It is also a measure of the body's inertia, the resistance to acceleration when a net force is applied. The mass of an object is a measure of the object's inertial property, or the amount of matter it contains. An object's mass also determines the strength of its gravitational attraction to other bodies. In effect, the resistance that a body of matter offers to a change in its speed or position upon the application of a force. The greater the mass of a body, the smaller the change produced by an applied force. The unit of mass in the International System of Units (SI) is the kilogram. The mass of an object can be measured using the electronic balance, top pan balance, triple beam balance etc.

Weight is the force exerted on the mass of a body by a gravitational field. It is said to be a body's relative mass or the quantity of matter contained by it, giving rise to a downward force. In the metric system, units of mass and weight are separate. The S.I unit of weight is the newton (N), which is 1 kilogram metre per second squared. It is the force required to accelerate a 1-kg mass by 1 m/s^2.

How to Measure Mass Using a Triple Beam Balance

A triple beam balance is a device used in measuring mass with high precision. The triple beam balance comprises a beam supported on a fulcrum. On one side of this beam, is a pan on which the object to be measured is placed, while on the other side, the beam is split into three parallel beams, each carrying a known weight and together culminating into a pointer pointing to a fixed scale. The weights are slid on their respective beams until zero reading is obtained and a state of balance is achieved.

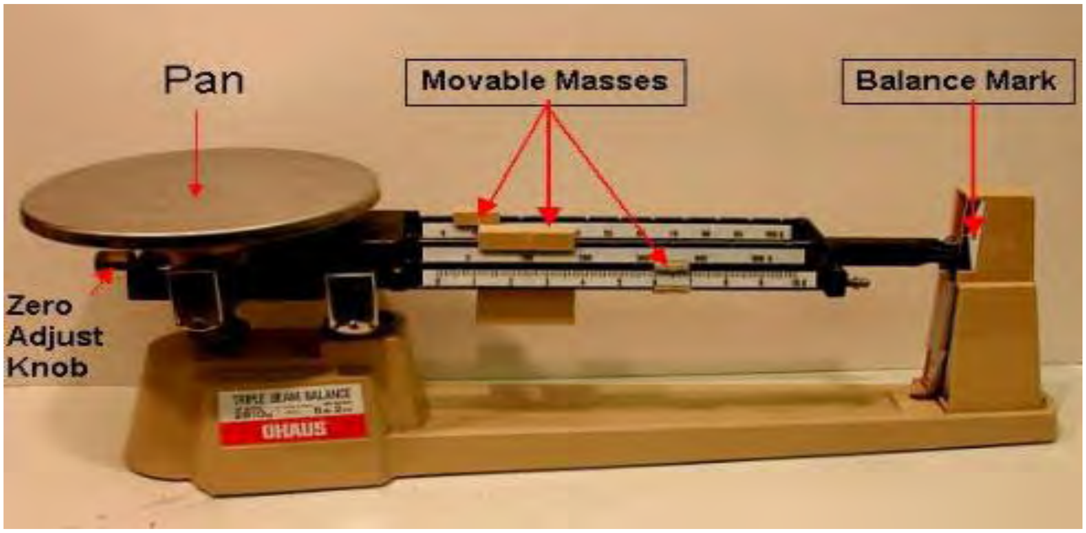

Figure 3.7: A picture of a tipple beam balance

- With the pan empty, transport all three riders on the three beams to the far left. Check the pointer and scale to make sure they are both zero. If it doesn't, calibrate the scale by twisting the adjustment knob until it reads zero.
- After calibration, centre the object to be measured on the pan. The pointer will be moved away from zero. Slide the 100 g rider to the left slowly from notch to notch, until the pointer drops below the zero mark. At this point move the rider back a notch. For example, if your object weighs 485 g, then the pointer will drop below zero when the rider is put on the notch representing 500 g. So, you will have to slide it back to the 400 g notch.
- Now, move the 10 g rider from notch to notch as you did with the 100 g notch until the pointer falls below zero, at which point you must move it back a notch. If your object weighs 485 g, your 10 g rider will go below zero at the 90 g notch once again. After that, you must return it to the 80 g notch.
- Finally, carefully move the 1 g rider along its beam until the pointer coincides with zero. Because this beam lacks notches, you must keep an eye on the pointer while sliding the rider

down it and halt as soon as it hits zero. In the above example, when the rider achieves 5 g, the pointer will read zero.

- Take the total of all the three numbers indicated by the positions of the three riders to get the mass of the object on the pan.

For example, the mass of the object from the diagram is: 40 g + 0 g +1 g = 41 g

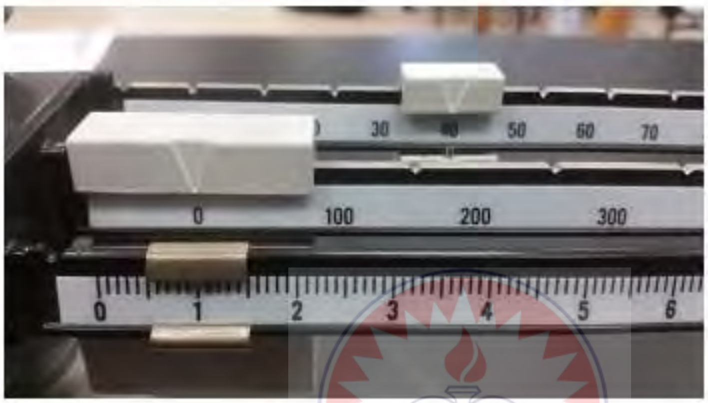

Fig 3.8: Diagrammatic representation on taking reading from a triple beam balance.

HOW TO MEASURE WEIGHT USING A SPRING BALANCE

Figure 3.9: A picture of a spring balance

The spring balance helps us to find the weight of an object. It consists of a spring fixed at one end and a hook attached to a rod at the other end. It works by Hooke's law which explains that the addition of weight produces a proportional increase in the length of the spring. A pointer is attached to the rod which slides over a graduated scale on the right. The spring extends according to the weight attached to the hook and the pointer reads the weight of the object on the scale.

How to Measure Mass Using an Electronic Balance

Figure 3.10: A picture of an electronic balance

Electronic balance is an instrument used in the accurate measurement of weight of materials. Electronic balance is a significant instrument for the laboratories for precise measurement of chemicals which are used in various experiments.

- Place the electronic balance on a flat surface.
- Press the ON button and wait for the balance to show zeroes on the digital screen.
- Use a container for your object to be massed. (Never place directly on the balance)
- Record the mass of the empty container (M_1).
- Carefully add the substance to the container. Ideally this is done with the container still on the platform of the balance.

- Record the mass as indicated by the digital display(M_2).
- Subtract the two masses recorded. (M_2- M_1).

Measurement of Volume

Volume is a scalar quantity expressing the amount of three-dimensional space enclosed by a closed surface. For example, the space that a substance (solid, liquid, gas or plasma) or 3D shape occupies or contains. Volume of a container is generally understood to be the capacity of the container. Volume is often quantified numerically using the SI derived unit, the cubic metre. The volume of a container if generally understood to be the capacity of the container; that is the amount of fluid (gas or liquid) that the container could hold, rather than the amount of space the container itself displaces. Three dimensional mathematical shapes are also assigned volumes. Volumes of some simple shapes, such a regular, straight-edge and circular shapes can be easily calculated using arithmetic formulas. Volumes of complicated shapes can be calculated with integral calculus if a formular exists for a shape's boundary. One-dimensional figure [such as lines] and two-dimensional shapes {such as squares} are assigned zero volume in the three-dimensional space.

Geometric Shape Name:	Geometric Shape:	Volume Formula:
Cube		Volume = a^3 , where a is length of each side.
Rectangular Prism		Volume = l × w × h , where l is length, w is width and h is height.
Sphere		Volume = 4/3 πr^3 , where r is the radius.
Cylinder		Volume = $\pi r^2 h$, where r is the radius and h is the height.
Cone		Volume = 1/3 $\pi r^2 h$, where r is the radius and h is the height.

Figure 3.11: Diagrammatic representation of basic solid geometric shapes using formulas.

How to Measure Volume Using Volumetric Flask, Beakers, Graduated Cylinder and Pipette.

Volumetric Flask

A volumetric flask is a lab glass or plasticware used to prepare a solution. It is used to make up a solution to a known volume. Volumetric flasks are used to measure volumes much more precisely than beakers or Erlenmeyer flasks. These flasks are available in a range of 1 mL to 2 L. They aren't graduated though. Each flask is designed to hold a specific volume. Some flasks are designed to hold 100 mL of liquids, while others hold only 50 mL. The flask should be filled to the etched mark on its neck to achieve the correct volume.

Figure 3.12: Image of a volumetric flask

Beakers

Beakers can be used to make coarse measurements of volumes, provided that graduated volume levels are printed on the side of the beaker (not all beakers have these marks). They are usually accurate to within 5%. Beakers are available in a wide range of sizes, from one millilitre up to several litres. A beaker is distinguished from a flask by having straight rather than sloping sides. It's uses include the preparation of solutions of known concentration.

Figure 3.13: Image of a beaker

Graduated Cylinders

Graduated cylinders are transparent cylinders with finely divided markings known as graduations marked on their side. They represent a significant improvement in accuracy over beakers and flasks generally to within 1%. Thus, a 10 ml graduated cylinder will be accurate to within 0.1 ml. Graduated cylinders are manufactured in sizes ranging from 5 ml to 2000 ml. As with beakers and flasks, graduated cylinders are available in either glass or plastic; glass is easier to clean, but more fragile and expensive than plastic.

Figure 3.14: Image of a graduated cylinder

Pipettes

Pipettes are slender tubes, typically 12 to 24 inches long. They may measure a predetermined volume such as 25.00 ml or 10.00 ml. They may also have graduations that allow odd and fractional volumes to be delivered. They are generally accurate to within 0.02 ml and are thus classified as volumetric glassware. When you squeeze the rubber bulb on the pipette, the suction from the expanding bulb draws liquid into the pipette. The operating principle is much the same as sucking liquid through a straw, but without the hazard of requiring mouth-to-glassware contact, which is strictly prohibited in laboratories. Some pipettes are single-use devices made of disposable plastic.

Figure 3.15: Image of a pipitte

Progressive Test

1. Define mass and weight. 5mrks
2. What is the S.I unit of mass and weight? 2mrks

3. List three instruments used for measuring mass. 3mrks
4. Briefly explain how to use a triple beam balance in taking measurement. 5mrks
5. Briefly explain how to use an electronic balance in taking measurement. 5mrks

3.9.3 Phase 3: Post- Intervention Phase

The post-intervention phase of the study involved monitoring the effects of the intervention strategies on the acquisition and development of requisite scientific process skills, conceptual understanding and performance by the students. This was done by organising a post-laboratory test where students were put into groups. Each group was observed using an observation checklist to know how their process skills have improved after the intervention activity. A post-intervention questionnaire was also given out to each student to determine the impact of the intervention on their conceptual understanding. The responses were judged by whether they addressed the expected outcome and reflected acquisition of concepts taught. A five-point Likert scale was used to obtain data on the pre-conceptual skills of students in measurement. On the five-point Likert scale, scores of 1 and 2 were considered as high scores whereas 4 and 5 were designated low scores. A score of 3 indicated an average score, interpreted as being neutral about the concerned attribute. Also, a general post-test was conducted and the scores obtained by the students during this phase was subjected to evaluate their performance after the intervention.

3.9.4 Data Analysis Procedure

Getting raw data and transforming it into knowledge that users can use to make decisions is the process of data analysis. In order to find answers, test hypotheses, or refute theories, data is gathered and analysed. According to Amoani (2015) as cited by Kwabla et al. (2017), data analysis has multiple approaches depending on the type of research design the researcher has chosen. The data was analysed in this study based on the students' improvement after each lesson, which was accomplished through the use of action research. A mixed method of data analysis was employed in this study. The qualitative data was analysed using descriptive tatistics whilst the quantitative data was analysed using inferential statistics. The results obtained in each case were based on the progress students had made in each lesson as indicated by their performance. Both qualitative and quantitative analysis was chosen because the Researcher needs to know the effect of the intervention at every stage to plan and meet the demands of students since the action research is aimed at improving the teaching and learning process in classrooms.

CHAPTER FOUR

RESULTS, DATA PRESENTATION AND ANALYSIS

4.0 Overview

This chapter deals with the presentation of results and findings along the research questions. The discussions were based on students' engagement on laboratory activities and teaching of concepts under measurements as well as learning activities that went on in the classroom and laboratory. Data collected from students' laboratory test, weekly intervention exercises after lessons and questionnaires were analysed qualitatively and quantitatively. The information collected during the research has been analysed in terms of descriptive and inferential statistics. Statistical analyses were carried out using statistical package for social science (SPSS) version 26 and Microsoft Excel 2016. A number of tables and charts have been constructed for easy presentation of data. The students' responses were mainly presented in the form of frequencies and percentages. Descriptive analysis of results was done to provide the basis for the findings on student's process skills and conceptual understanding whilst an inferential analysis was done to provide the basis for the findings on students' performance.

4.1 Analysis of Findings Related to Research Questions

Research Question 1: What process skills are students unable to perform under measurement in physics?

This question was posed to identify some process skills students are unable to perform under measurement in physics during practical sessions. In order to identify these process skills, a laboratory test was conducted before and after the intervention procedure. Students were then grouped and being observed while exhibiting their process skills acquisition in using series of measuring instruments and manipulating objects presented. An observation checklist consisting of a rubric was used as an evaluation tool. The results from the pre-observation and post-observation are presented below in Table 4.1 and Table 4.2.

Table 4.1: Researcher's observation prior to students pre-laboratory test

STATEMENT	**DONE CORRECTLY**		**NOT DONE CORRECTLY**	
	F	**P %**	**F**	**P %**
1. Students working collaboratively.	2	20	8	80
2. Students identify an appropriate instrument for measuring.	3	30	7	70
3. Students record least count of measuring instrument in use.	0	0	10	100
4. Students identify zero error of measuring instrument in use.	0	0	10	100
5. Students apply a correct standard unit of measurement.	4	40	6	60
6. Students avoid parallax error when taking readings.	5	50	5	50
7. Students read standard measures to describe the dimensions of the object in use.	1	10	9	90
8. Students record appropriate readings on the measuring instrument in use.	3	30	7	70
9. Students organise data and draw conclusions from it.	2	20	8	80
10. Students properly handle the measuring instruments.	5	50	5	50

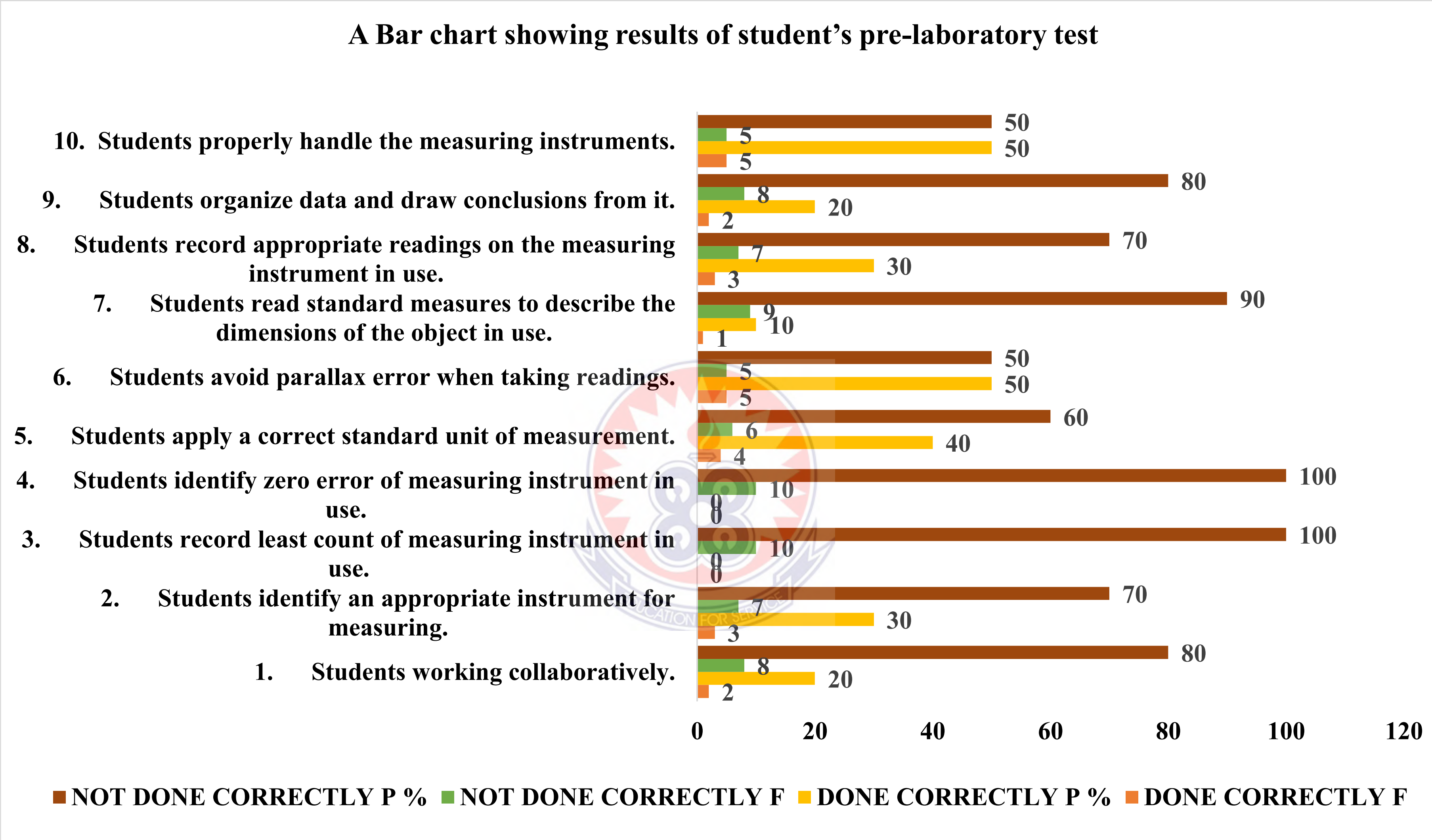

Figure 4.1: Bar chart showing results of student's pre-laboratory test

Descriptive Statistical Analysis on Student's Pre-laboratory Test

Data from Table 4.1 shows that two (2) groups comprising 20% of the students worked collaboratively and eight (8) groups comprising 80% of the students did not work collaboratively during the pre-laboratory test. Three (3) groups comprising 30% of the students were able to identify an appropriate instrument for measuring. Seven (7) groups representing 70% of the students were not able to identify an appropriate instrument for measuring. Ten (10) groups representing 100% of the students were not able to record the least count of the measuring instrument in use. Ten (10) groups comprising of 100% of the students were not able to identify the zero error of the measuring instrument in use. Four (4) groups comprising of 40% of the students were able to apply a standard unit of measurement. Six (6) groups representing 60% of the students were not able to apply a standard unit of measurement. Five (5) groups representing 50% of the students were able to avoid parallax error when taking readings. Five (5) groups representing 50% of the students were not able to avoid parallax error when taking readings. One (1) group comprising of 10% of the students were able to read standard measures to describe the dimensions of the object in use. Nine (9) groups representing 90% of the students were not able to read standard measures to describe the dimensions of the object in use. Three (3) groups representing 30% of the students were able to record an appropriate reading on the measuring instrument in use. Seven (7) groups representing 70% of the students were not able to record an appropriate reading on the measuring instrument in use. Two (2) groups representing 20% of the students were able to organise data obtained and draw conclusions from it. Eight (8) groups representing 80% of the students were not able to organise data and draw conclusions from it. Five (5) groups representing 50% of the students were able to handle the measuring instruments. Five (5) groups representing 50% of the students were not able to handle the measuring instruments.

Table 4.2: Researcher's observation prior to students post-laboratory test

STATEMENT	DONE CORRECTLY		NOT DONE CORRECTLY	
	F	**P %**	**F**	**P %**
1. Students working collaboratively.	9	90	1	10
2. Students identify an appropriate instrument for measuring.	10	100	0	0
3. Students record least count of measuring instrument in use.	8	80	2	20
4. Students identify zero error of measuring instrument in use.	9	90	1	10
5. Students apply a correct standard unit of measurement.	10	100	0	0
6. Students avoid parallax error when taking readings.	10	100	0	0
7. Students read standard measures to describe the dimensions of the object in use.	8	80	2	20
8. Students record appropriate readings on the measuring instrument in use.	9	90	1	10
9. Students organise data and draw conclusions from it.	7	70	3	30
10. Students properly handle the measuring instruments.	10	100	0	0

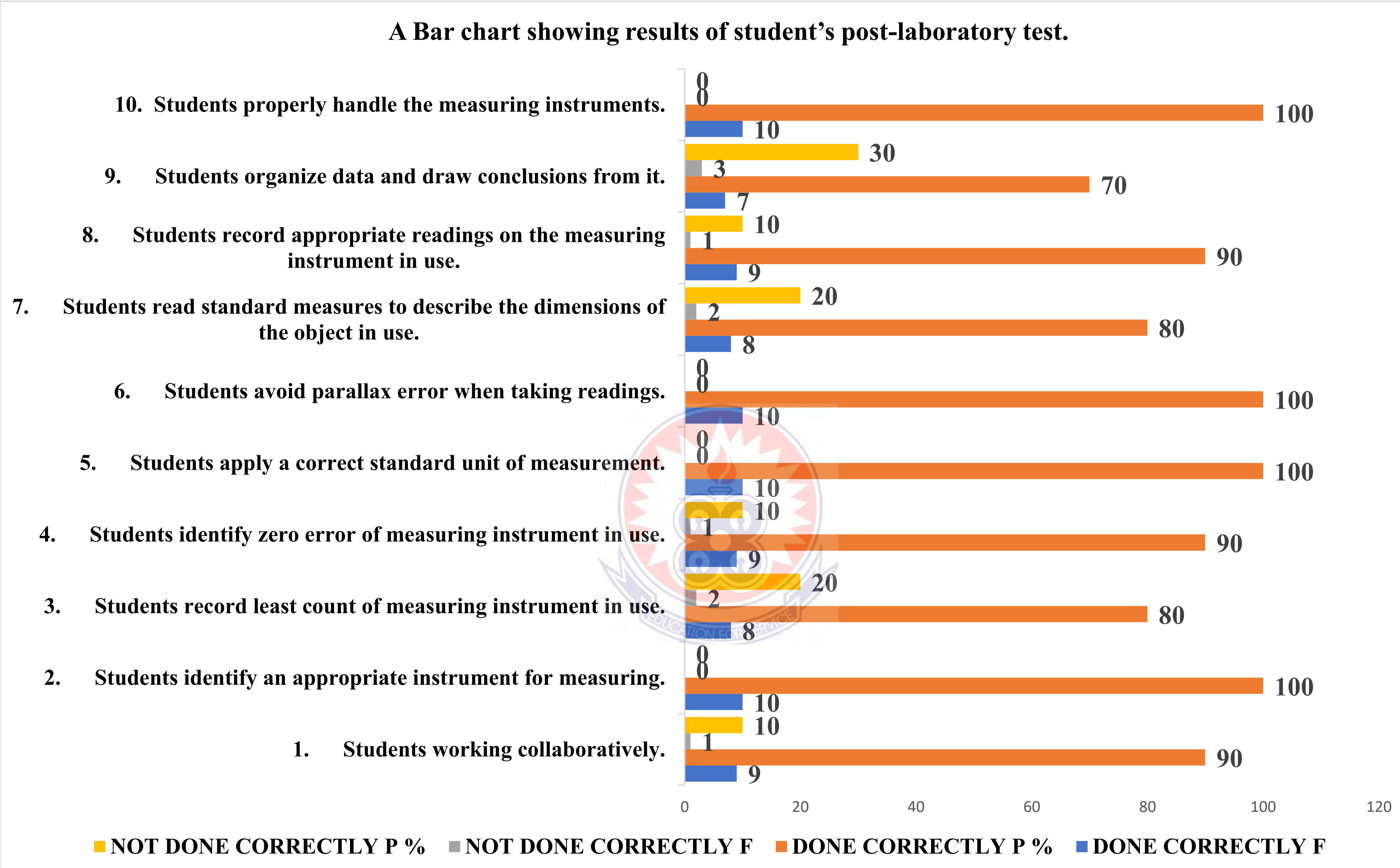

Figure 4.2: Bar chart showing results of student's post-laboratory test.

4.2 Descriptive Statistical Analysis on Student's Post-laboratory Test

Data from Table 4.2 shows that nine (9) groups comprising 90% of the students worked collaboratively and one (1) group comprising 10% of the students did not work collaboratively during the post-laboratory test. Ten (10) groups comprising 100% of the students were able to identify an appropriate instrument for measuring. Eight (8) groups representing 80% of the students were able to record the least count of the measuring instrument in use. Two (2) groups representing 20% of the students were not able to record the least count of the measuring instrument in use. Nine (9) groups comprising of 90% of the students were able to identify the zero error of the measuring instrument in use. One (1) group comprising of 10% of the students were not able to identify the zero error of the measuring instrument in use. Ten (10) groups comprising of 100% of the students were able to apply a standard unit of measurement. Ten (10) groups representing 100% of the students were able to avoid parallax error when taking readings. Eight (8) groups comprising of 80% of the students were able to read standard measures to describe the dimensions of the object in use. Two (2) groups representing 20% of the students were not able to read standard measures to describe the dimensions of the object in use. Nine (9) groups representing 90% of the students were able to record an appropriate reading on the measuring instrument in use. One (1) group representing 10% of the students were not able to record an appropriate reading on the measuring instrument in use. Eight (8) groups representing 80% of the students were able to organise data and draw conclusions from it. Two (2) groups representing 20% of the students were not able to organise data obtained and draw conclusions from it. Ten (10) groups representing 100% of the students were able to handle the measuring instruments.

Findings from Observation Made Prior to Student's Laboratory Test.

From Table 4.1, majority of the students representing 80% lack collaborative skills in conducting practical's related to measurement in physics. 70% of the students also lack identification skills whiles 100% of the students were unable to record the least count and zero error of a measuring instrument. 60% of the students were unable to apply a correct standard unit of measurement as 50% of them could not avoid parallax error when taking reading. About 90% of the students could not read standard measures to describe the dimensions of an object. Also 70% of the students lack recording skills as 80% of the students could not organise data and draw conclusions from it. Lastly, 50% of the students lack the skills of handling an instrument. According to Millar (2004), the use of practical activities is a necessity to increase students science process skills. Okafor (2018) emphasised that, in order to create knowledge, solve issues and conduct experiment, science process skills must be employed. This led to the intervention of using practical activities to improve students' science process skills. From Table 4.2, it could be seen that student's skills improved amicably during the post-laboratory test. This could be as a result of students learning new skills adopted from the intervention activity.

Research Question 2: What are the pre-conceptual skills of students in measurement in physics?

This question was asked to find out student's pre-conceptual skills during practical sessions involving measurement. In order not to make a final conclusion on the observation made during the laboratory test, a five-point Likert scale questionnaire was given to the students to identify their pre-conceptual skills in measurement in physics with respect to the observation made. The results from the questionnaires are presented below in Table 4.3 and Table 4.4.

Table 4.3: Results of pre-intervention questionnaire on student pre-conceptual skills

	AGREE		UNCERTAIN		DISAGREE	
STATEMENT	**F**	**P %**	**F**	**P %**	**F**	**P %**
1. Can you identify an appropriate instrument for measuring an object?	5	10.2	7	14.3	37	75.5
2. Can you apply a correct standard unit of measurement?	3	6.1	5	10.2	41	83.7
3. Are you able to avoid parallax error when taking reading?	8	16.3	7	14.3	34	69.4
4. Can you use standard measures to describe the dimensions of an object?	0	0.0	10	20.4	39	79.6
5. Can you differentiate between the length, breadth and height of an object?	3	6.1	6	12.2	40	81.7
6. Can you identify zero error in a measuring instrument?	0	0.0	4	8.2	45	91.8
7. Can you find the least count of a measuring instrument?	2	4.1	5	10.2	42	85.7
8. Can you record appropriate readings on a measuring instrument?	2	4.1	8	16.3	39	79.6
9. Can you organise data and draw conclusions from it?	3	6.1	5	10.2	41	83.7

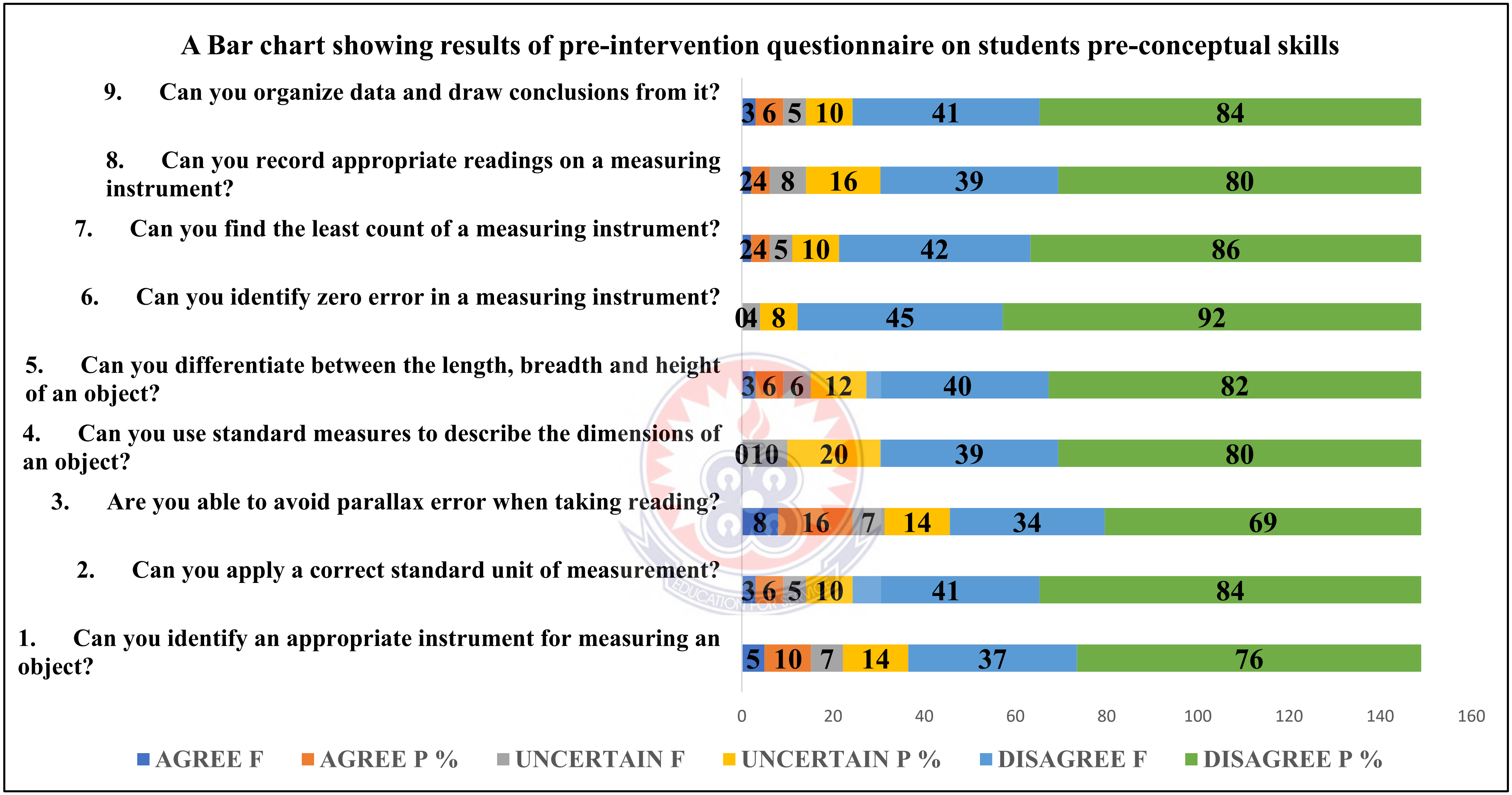

Figure 4.3: Bar chart showing results of pre-intervention questionnaire on students pre-conceptual skills

4.3 Descriptive Analysis on Students Pre-conceptual Skills Before Intervention.

Item 1 of the questionnaire in Table 4.3 required the students to state whether they can identify an appropriate instrument for measuring an object. The result showed thirty-seven (37) students representing 75.5% disagreed that they can identify an appropriate instrument for measuring an object and five (5) students representing 10.2% agreed they can identify an appropriate instrument for measuring an object. Seven (7) students representing 14.3% were uncertain with the statement above.

Item 2 of the questionnaire in Table 4.3 required the students to state whether they can apply a correct standard unit of measurement. The results indicated that forty-one (41) students representing 83.7% disagreed that they can apply a correct standard unit of measurement and three (3) students representing 6.1% agreed they can apply a correct standard unit of measurement. Five (5) students representing 10.2% were uncertain with this statement.

Item 3 of the questionnaire in Table 4.3 required the students to state whether they are able to avoid parallax error when taking reading. The result from the analysis showed that thirty-four (34) students representing 69.4% disagreed that they are able to avoid parallax error when taking reading and eight (8) students representing 16.3% agreed that they are able to avoid parallax error when taking reading. Seven (7) students representing 14.3% were uncertain with this statement.

Item 4 of the questionnaire in Table 4.3 required the student to indicate if they can use standard measures to describe the dimensions of an object. The results from the analysis showed that thirty-nine (39) students representing 79.6% disagreed that they can use standard measures to describe the dimensions of an object. Ten (10) students also representing 20.4% were uncertain that they can use standard measures to describe the dimensions of an object. None of the students agreed with this statement.

Item 5 of the questionnaire in Table 4.3 required the student to state whether they can differentiate between length, breadth and height of an object. The result from the analysis indicated that forty (40) students representing 81.7% disagreed that they can differentiate between length, breadth and height of an object. Three (3) students also representing 6.1% of the students agreed that they can differentiate between length, breadth and height of an object. Six (6) students representing 12.2% remained uncertain with the statement.

Item 6 of the questionnaire in Table 4.3 required the students to state whether they can identify the zero error in a measuring instrument. The results of the analysis indicated that forty-five (45) students representing 91.8% disagreed whether they can identify the zero error in a measuring instrument and no student agreed with the statement. Four (4) students also representing 8.2% were uncertain that they can identify the zero error in a measuring instrument.

Item 7 of the questionnaire in Table 4.3 required the students to state whether they can find the least count of a measuring instrument. The results indicated that forty-two (42) students representing 85.7% disagreed that they can find the least count of a measuring instrument. Two (2) students also representing 4.1% of the students agreed that they can find the least count of a measuring instrument. Five (5) students representing 10.2% were uncertain with the statement.

Item 8 of the questionnaire in Table 4.3 required the students to state whether they can record appropriate readings on a measuring instrument. The results indicated that thirty-nine (39) students representing 79.6% disagreed that they can record appropriate readings on a measuring instrument. Two (2) students also representing 4.1% of the students agreed that they can record appropriate readings on a measuring instrument. Eight (8) students representing 16.3% remained uncertain with the statement.

Item 9 of the questionnaire in Table 4.3 required the students to state whether they can organise data and draw conclusions from them. The results indicated that forty-one (41) students representing 83.7% disagreed that they can organise data and draw conclusions from them. Three (3) students also representing 6.1% of the students agreed that they can organise data and draw conclusions from them. Five (5) students representing were uncertain10.2% with the statement.

Table 4.4: Results of post-intervention questionnaire on students pre-conceptual skills

STATEMENT	AGREE		UNCERTAIN		DISAGREE	
	F	P %	F	P %	F	P %
1. Can you identify an appropriate instrument for measuring an object?	49	100.0	0	0.0	0	0.0
2. Can you apply a correct standard unit of measurement?	49	100.0	0	0.0	0	0.0
3. Are you able to avoid parallax error when taking reading?	43	87.8	5	10.2	1	2.0
4. Can you use standard measures to describe the dimensions of an object?	45	91.8	4	8.2	0	0.0
5. Can you differentiate between the length, breadth and height of an object?	47	95.9	2	4.1	0	0.0
6. Can you identify zero error in a measuring instrument?	49	100.0	0	0.0	0	0.0
7. Can you find the least count of a measuring instrument?	46	93.8	2	4.1	1	2.0
8. Can you record appropriate readings on a measuring instrument?	49	100.0	0	0.0	0	0.0
9. Can you organise data and draw conclusions from it?	44	89.9	3	6.1	2	4.0

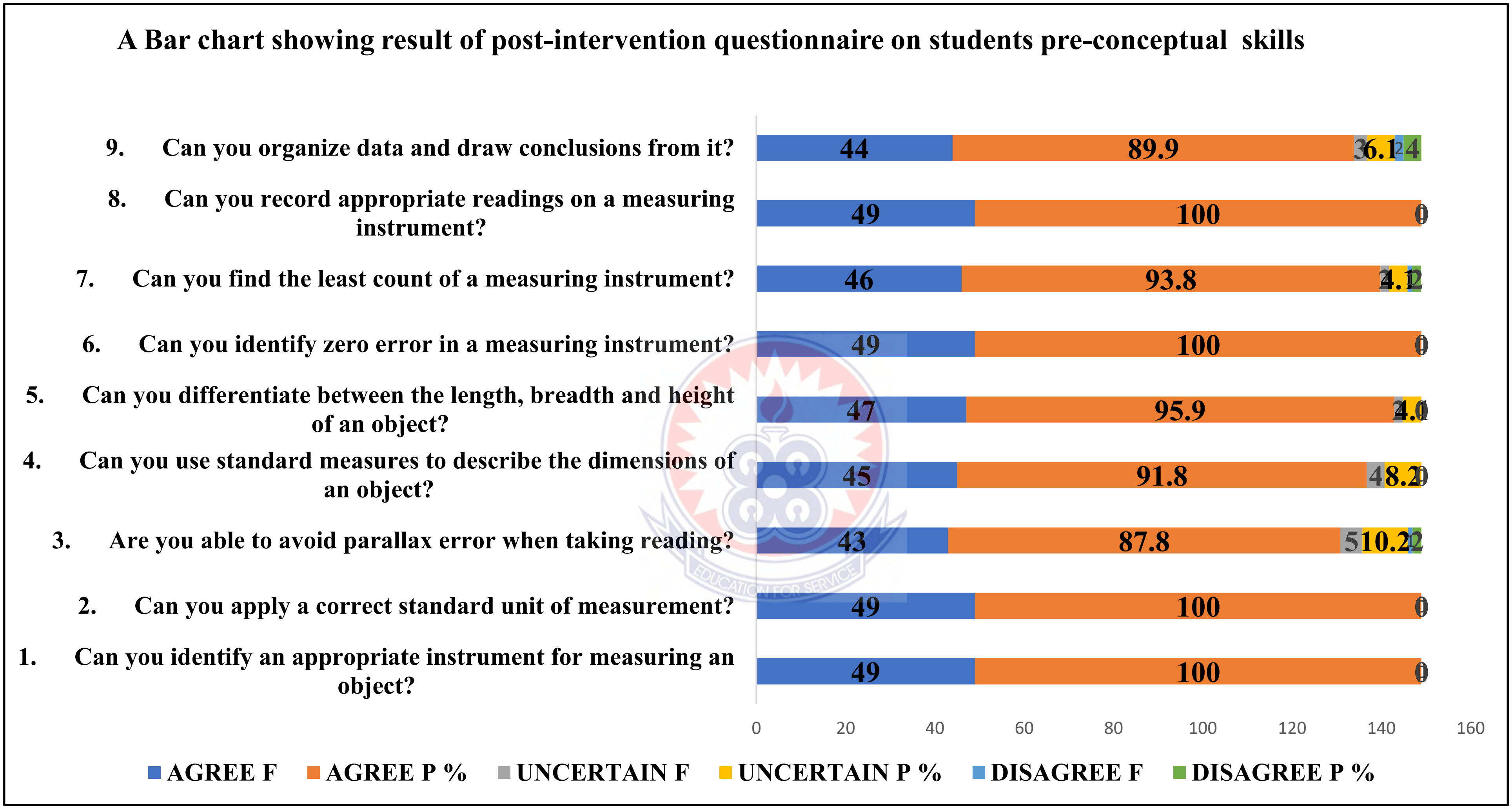

Figure 4.4: Bar chart showing results of post-intervention questionnaire on students pre-conceptual skills

4.4 Descriptive Statistical Analysis on Students Pre-conceptual Skills after Intervention.

Item 1 of the questionnaire in Table 4.4 required the students to state whether they can identify an appropriate instrument for measuring an object. The result showed forty-nine (49) students representing 100% agreed that they can identify an appropriate instrument for measuring an object and no student disagreed they can identify an appropriate instrument for measuring an object. None of the students were uncertain with this statement.

Item 2 of the questionnaire in Table 4.4 required the students to state whether they can apply a correct standard unit of measurement. The results indicated that forty-nine (49) students representing 100% agreed that they can apply a correct standard unit of measurement and none of the students disagreed they can apply a correct standard unit of measurement. From the table, none of students were uncertain with this statement.

Item 3 of the questionnaire in Table 4.4 required the students to state whether they are able to avoid parallax error when taking reading. The result from the analysis showed that forty-three (43) students representing 87.8% agreed that they are able to avoid parallax error when taking reading and one (1) student representing 2.0% disagreed that they are able to avoid parallax error when taking reading. Five (5) students representing 10.2% were uncertain with the statement.

Item 4 of the questionnaire in Table 4.4 required the student to indicate if they can use standard measures to describe the dimensions of an object. The results from the analysis showed that forty-five (45) students representing 91.8% agreed that they can use standard measures to describe the dimensions of an object. Four (4) students also representing 8.2% were uncertain that they can use standard measures to describe the dimensions of an object. From the table no student disagreed with the statement above.

Item 5 of the questionnaire in Table 4.4 required the student to state whether they can differentiate between length, breadth and height of an object. The result from the analysis indicated that forty-seven (47) students representing 95.9% agreed that they can differentiate between length, breadth and height of an object. Two (2) students also representing 4.1% of the students were uncertain that they can differentiate between length, breadth and height of an object. No student disagreed with the statement.

Item 6 of the questionnaire in Table 4.4 required the students to state whether they can identify the zero error in a measuring instrument. The results of the analysis indicated that forty-nine (49) students representing 100.0% agreed they can identify the zero error in a measuring instrument and no student disagreed with the statement. None of the students were uncertain that they can identify the zero error in a measuring instrument.

Item 7 of the questionnaire in Table 4.4 required the students to state whether they can find the least count of a measuring instrument. The results indicated that forty-six (46) students representing 93.8% agreed that they can find the least count of a measuring instrument. One (1) student representing 2.0% of the students disagreed that they can find the least count of a measuring instrument. Two (2) students representing 4.1% were uncertain with this statement.

Item 8 of the questionnaire in Table 4.4 required the students to state whether they can record appropriate readings on a measuring instrument. The results indicated that forty-nine (49) students representing 100% agreed that they can record appropriate readings on a measuring instrument. No student disagreed that they can record appropriate readings on a measuring instrument. None of the students were uncertain with the statement above.

Item 9 of the questionnaire in Table 4.4 required the students to state whether they can organise data and draw conclusions from them. The results indicated that forty-four (44) students representing 89.9% agreed that they can organise data and draw conclusions from them. Three (3) students also representing 6.1% of the students agreed that they can organise data and draw conclusions from them and two (2) students representing 4.0% disagreed with the statement. Three (3) students representing 6.1% were uncertain that they can organise data and draw conclusions from them.

Findings Made from Student's Pre-conceptual skills in Measurement in Physics.

From Table 4.3, the pre-conceptual skills of student's inability to identify an appropriate instrument for measuring an object was in relation to the observation made during the pre-laboratory test in Table 4.1. About 83% of the students disagreed that they can apply a correct standard unit of measurement. 69% of the students shared their thoughts on their inability to avoid parallax error when taking readings. Also 80% disagreed on using standard measures to describe the dimensions of an object which was also in relation to the observation made from Table 4.1. Majority of the students representing 82% indicated they cannot differentiate between the length, breadth and height of an object. In respect to the observation made from Table 4.1, 92% of the students disagreed on their ability to identify zero error in a measuring instrument. 86% indicated their inability to identify the least count of a measuring instrument. About 80% and 84% of the students disagreed to record appropriate reading on a measuring instrument as well as organise data and draw conclusion from it respectively. The use of practical activities during the intervention phase resulted in changing the pre-conceptual skills of students in measurement in physics. Results from Table 4.4 showed a huge positive margin toward the pre-conceptual skills of students in measurement in physics.

Research Question 3: What influence will the use of practical activities have on improving students' conceptual understanding on measurement in physics?

This question sought to find out how the use of practical activities will improve students conceptual understanding on measurement in physics. An open-ended questionnaire made up of ten questions were given to students to provide answers based on their conceptual knowledge on measurement in physics. The results from their pre-responses and post-responses from the questionnaires provided are indicated in the Table 4.5.

4.5 Analysis of Students Conceptual Understanding on Measurement in Physics.

Table 4.5: Results on student's response on their conceptual understanding from pre-intervention and post-intervention questionnaire**.**

Question	Student's Pre-responses	Expected response	Student's Post-responses
1. What determines the precision of a measurement?	It is when you determine but you are not sure.	***Depends on the instrument used and its least count***	Depends on the instrument used and its least count
	How one takes the measurement		How close the measured values are to each other
	Is the correct measurement of the object.		The consistency of the measured values

2. What is uncertainty in measurement?	Measurement not taken perfectly	***Range of possible values within which the true values of the measurement lie***	Range of possible values
	No idea		The true value
	By using micrometre screw gauge to get the measurement		The actual values of the measurement
3. A student measures a distance several times. The reading lies between 49.8cm and 50.2cm. What is the best way of recording this?	50.1cm	***50.00 ± 0.2cm***	50.00 ± 0.2cm
	52cm		52cm or 50cm
	50 cm is the best way		Find average of the two values, that is 50cm.
4. The number of significant figures in the measurement of 0.00807600cm is?	8 significant figures	***6 significant figures***	6 significant figures
	3 significant figures		6 significant figures
	No significant		8 significant figures
5. For an answer to be complete, the units need to be specified. Why?	It shows you what you should do	***Any physical quantity is made relative to a particular standard or unit***	The unit defines the quantity measured
	It help you to understand		Because it is relative to a particular standard.

	It means different thing.		To know the exact value measured
6. What is least count error?	Error by the one using the instrument	***An error associated with the resolution of the instrument in used.***	Is the uncertainty in the smallest unit an instrument can measure.
	No response		When the reading of the instrument does not start from zero
	If you don't use the right instrument.		An error associated with the resolution of instrument.
7. How can least count error be reduced during measurement?	No idea	***Replacing the instrument with a higher resolution instrument and adapting better experimental techniques***	Replacing the instrument with higher resolution.
	Being careful when taking the measurement.		Using proper and well calibrated instrument
	By using the minimum measurement		Taking multiple readings and finding its average.
8. Can you find the diameter of a thin wire of length 2m using a ruler? State the	Yes, used in the right way	***No, because a thin wire has a very small diameter and cannot be measured with a ruler.***	No, a thin wire has a very small diameter.
	Yes, by putting the ruler in the		No, Ruler is used to measure the

reason for your answer?	length of a thin wire		length of the wire.
	No, a micrometre screw gauge is used to measure the diameter.		No, only micrometre screw gauge can be used.
9. What is the advantage of using International System (SI) of units?	It helps reduce measurement in physics error.	***SI unit has only one unit for each quantity and can easily be converted.***	For easy conversion of units.
	To avoid wrong answers		For easy identification of quantity measured.
	To know specific instrument to use		It is standard and known to all scientist
10. What is the difference between precision and accuracy in measurement?	No difference	***Precision is how close measurement of the same item are to each other AND Accuracy is the degree of closeness to a true value***	Accuracy refers to how close a measurement is to a standard value and precision refers to closeness of series of values in an experiment.
	Precision is when the correct instrument is used for the measurement while accuracy in measurement is when the exact		Precision is how close two or more measured values is but accuracy talks about the closeness of the measured value to the actual value.

	measurement is counted.	
	They means correct measurement	Accuracy is the degree of closeness to a true value whilst Precision is how close measurement of the same item are to each other.

Findings Made from How Practical Activities Will Improve Students Conceptual Understanding in Measurement in Physics

The conceptual understanding of students exposed to regular weekly intervention of practical activities and teaching of concepts related to measurement in physics improved tremendously. From Table 4.5, there is a clear indication of student's pre-responses being improved as compared to their post-responses of the questionnaire. This is evidence that the intervention strategy adopted had helped in improving students' conceptual understanding. This means students' lack of conceptual understanding in measurement in physics were to large extent, due to lack of practical activities and basic concepts in measurement in physics. Findings with respect to research question three was positive in that, the conceptual understanding of students exposed to practical activities did improve significantly. From the research literature, Sawyer (2008) stated that conceptual understanding involves the application of an explanation to certain novel situations that are previously known. The use of practical activities aimed at allowing students apply concepts into real-life situation as suggested by Sawyer (2008). Antwi et al (2021) also reported that practical work was a significant tool for developing students' scientific knowledge and habit of mind which concurs with the finding that practical activities contribute to increased ability to conceptual understanding. Based on the findings, a strong case can be made on the positive or improved effect of practical activities on the conceptual understanding of students in measurement in physics.

Research Question 4: What effect will the use of practical activities have on improving students performance in measurement in physics.

This question was posed to determine the effect to which frequent practical activities will improve students' performance in measurement in physics. A general test was organised to determine the level of their performance in measurement before and after the intervention activity. Weekly class exercises were also given at the end of each intervention activity to measure their level of performance. The scores obtained from the test as well as mean scores and standard deviations were calculated and have been presented below:

4.6 Analysis of Students Performance in Measurement in Physics.

Table 4.6: Results on students performance on weekly progressive test during intervention phase.

Scores obtained	Progressive Test 1 (No. of Students)	Progressive Test 2 (No. of students)	Progressive Test 3 (No. of Students)
0-5	12	4	0
6-10	14	8	5
11-15	8	16	14
16-20	15	21	30
Total	49	49	49

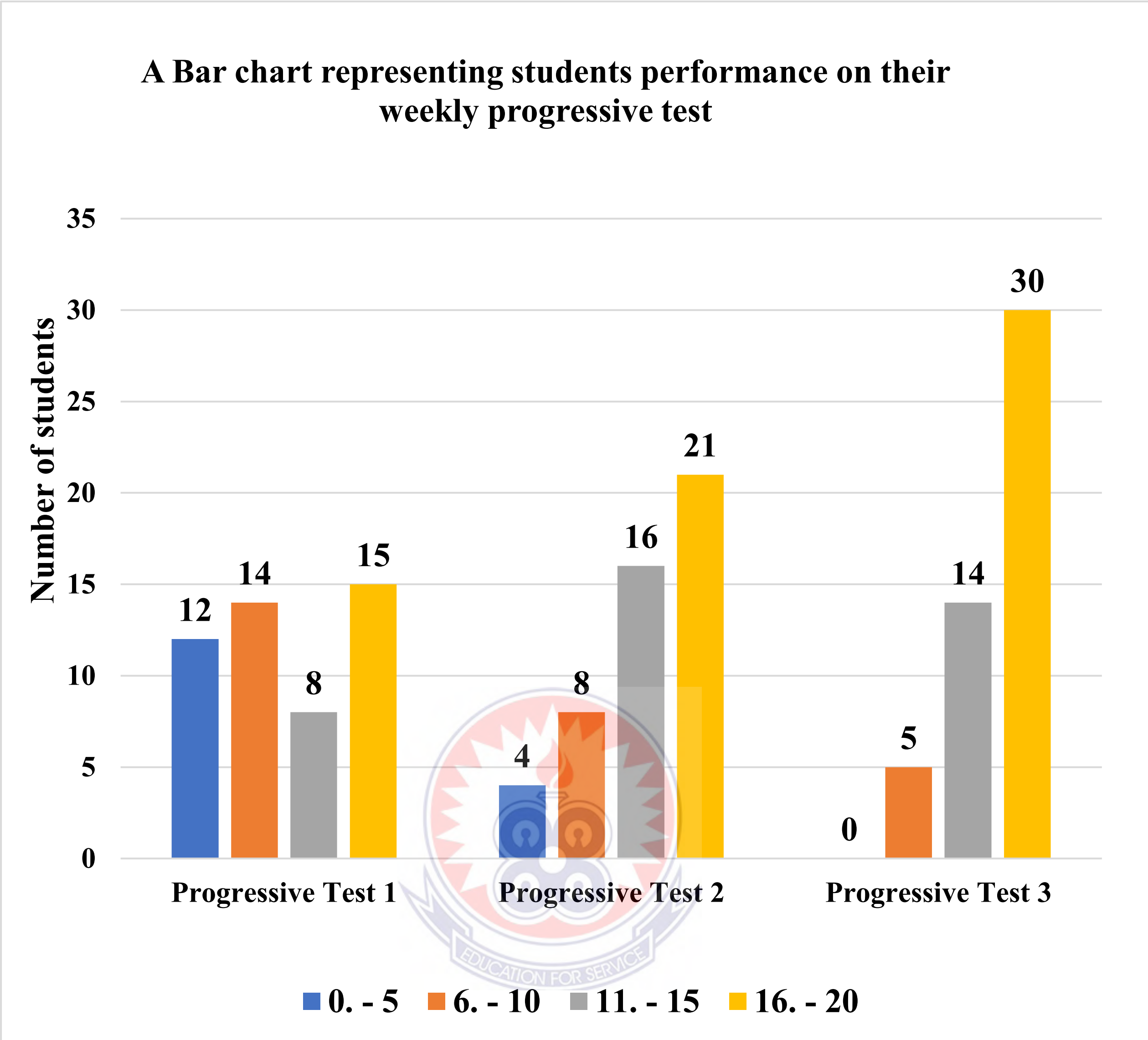

Figure 4.6: Bar chart representing students performance on their weekly progressive test

In progressive test one from Table 4.6, twelve (12) students scored 0-5 marks. Fourteen (14) students scored 6-10 marks. Eight (8) students scored 11-15 marks. Fifteen (15) students scored 16-20 marks.

Moreover, progressive test two indicated that four (4) students scored 0-5 marks. Eight (8) students scored 6-10 marks. Sixteen (16) students scored 11-15 marks. Twenty-one (21) students scored 16-20 marks.

In the last progressive test conducted, the result showed no student scored marks from 0-5 marks. Five (5) students scored 6-10 marks. Fourteen students scored 11-15 marks. Thirty (30) students scored 16-20 marks.

The bar chart in figure 4.6 above showed the test scores of students performance on their weekly progressive test. The results showed a remarkable improvement in the marks obtained by the students in each of the tests conducted.

Table 4.7: Results on performance of student's pre-test and post-test scores.

	Pre-Test		Post-Test	
Scores obtained	(No. of Students)	Percentage(%)	(No. of students)	Percentage(%)
0-10	12	25.5	0	0.0
11-20	35	71.4	5	10.2
21-30	2	4.1	24	49.0
31-40	0	0.0	14	28.6
41-50	0	0.0	6	12.2
Total	49	100.0	49	100.0

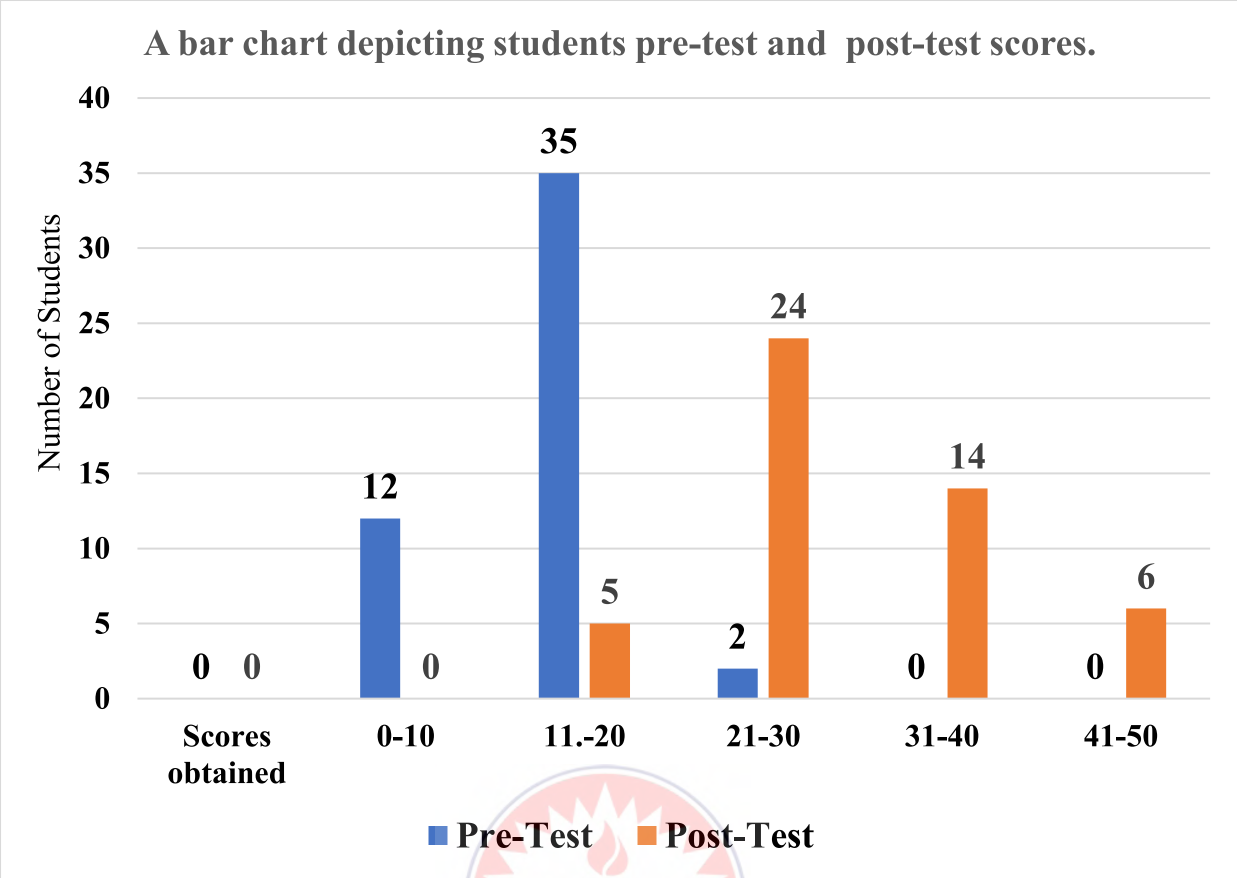

Figure 4.7: A bar chart depicting students pre-test and post-test scores.

From Table 4.7, the pre-test results indicated that twelve (12) students representing 25.5% scored between zero (0) to ten (10) marks. Thirty-five (35) students representing 71.4% scored between eleven (11) to twenty (20) marks. Two (2) students representing 4.1% scored between twenty-one (21) to thirty (30) marks. None of the students representing 0% scored between thirty-one (31) to forty (40) marks and forty-one (41) to fifty (50) marks.

However, the post-test results of the same group indicated an improvement in student's performance. None of the students representing 0% scored between zero (0) and ten (10) marks. Five (5) students representing 10.2% scored between eleven (11) to twenty (20) marks. Twenty-four (24) students representing 49.0% scored between twenty-one (21) to thirty (30) marks. Fourteen (14) students representing 28.6% scored between thirty-one (31) to forty (40) marks. Six (6) students representing 12.2% scored between forty-one (41) to fifty (50) marks.

Table 4.8: A Paired-Sample t-test of students pre-test and post-test scores**.**

Test	N	Mean	Std. Deviation	Degree of freedom	T-value	P-value
Pre-Test	49	13.6	4.4	48	16.13	0.010
Post-Test	49	29.7	7.2	48		

Significant; $p < 0.05$ **$T_{(0.05)} = 1.684$** **Not significant; $p > 0.05$**

From Table 4.8 above, the mean (29.7)of the post-test is higher than the mean and standard deviation (13.6, SD = 4.4) of the pre-test. This shows that the difference in performance of students post-test and pre-test is significant. However, the Paired sample t-test results indicated a calculated t-value of 16.8 and a p-value of 0.010. Comparing these two results indicates a high level of statistical significance between the pre-test and post-test scores since the tabulated t-vale is less than the calculated t-value and the P-value is less than 0.05. As a result, there is a statistically significant difference between the performance of student's pre-test and post-test scores when exposed to practical activities in measurement in physics. Hence the null hypothesis was rejected.

Findings Made from the Effect of Practical Activities on Students' Performance in Measurement in Physics.

The bar chart in Figure 4.7 above showed the test scores of students' performance for pre-test and post-test with a high improvement in their performance after engaging students with series of practical activities in measurement in physics. Also comparing the means of both test in Table 4.8 gave a clear indication of students performing better in the post-test as compared to the pre-test. This improvement of the performance could be attributed to students building upon their conceptual understanding and process skills from previous lessons taught. Findings with respect to research question four was positive in that, the performance of SHS 2 students exposed to series of practical activities have improved. According to performance statistics published by the West African Examination Council (WAEC) between 2018 and 2019, the WASSCE for School Candidates 2019 raw mean score of 27 out of 50 and a standard deviation of 07.92 with a candidature of 762340 indicates a low performance than that of WASSCE for School Candidates 2018, where a raw mean score of 28 out of 50 marks and a standard deviation of 07.62 with a candidature of 728924 was recorded (WAEC, 2019). This shows that the way science is taught in senior high schools does not correspond to how scientists work. It has been suggested that the situation could be improved by adopting a procedure where students identify problems, handle or manipulate objects, and conduct scientific experiments. In this regard, adopting the usage of practical activities in some selected topics in physics would curb the worrying situation of students not performing in physics since there have been a remarkable improvement after the intervention.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter provides the summary and findings of the research. The chapter also draws conclusion on the outcome of the study. Some recommendations and suggestions for further research were also discussed.

5.1 Summary

The purpose of the study was to find the effect of practical activities on student's process skills, conceptual understanding and performance in measurement in physics. Some research objectives raised from the study were to identify the process skills that students were unable to perform under measurement, determine the pre-conceptual skills of students towards the study of measurement in physics, determine the effect of practical activities on students' conceptual understanding in measurement in physics and assess the effect of practical activities on students' performance in measurement in physics. Action research was employed in this study. In this study, the researcher chose an intact class of a total sample size of forty-nine (49) physics students in Form two. The researcher used observational checklist, questionnaires and tests as instruments for the collection of data. A mixed method of data analysis was employed in this study. The qualitative data was analysed using descriptive statistics whilst the quantitative data was analysed using inferential statistics. Data collected were analysed by applying t-test, mean, standard deviation, percentages using statistical package for social science (SPSS) version 26.

5.2 Main Findings

The study aimed at finding the effect of practical activities on students' process skills, conceptual understanding and performance in measurement in physics. The following were the findings that emerged from the study:

1. Majority of the students representing 80% lack collaborative skills in conducting practical's related to measurement in physics. 70% of the students also lack identification skills whiles 100% of the students were unable to record the least count and zero error of a measuring instrument. 60% of the students were unable to apply a correct standard unit of measurement as 50% of them could not avoid parallax error when taking reading. About 90% of the students could not read standard measures to describe the dimensions of an object. Also 70% of the students lack recording skills as 80% of the students could not organise data and draw conclusions from it. Lastly, 50% of the students lack the skills of handling an instrument. The results from the post-laboratory test reported students having gain much experience in their process skills in measurement in physics. This is a clear indication that the use of practical activities in measurement has improved their process skills remarkably.
2. Students' pre-conceptual skills towards the study of measurement changed drastically indicating a positive effect on their process skills in measurement in physics. There was a clear indication of a positive change in their pre-conceptual skills of a five-point Likert scale questionnaire before and after the intervention activity.
3. The conceptual understanding of students exposed to regular weekly intervention of practical activities and teaching of concepts related to measurement in physics improved tremendously. From Table 4.5, there was a clear indication of student's pre-responses being improved as compared to their post-responses to the open-ended questionnaire.

This is evidence that the intervention strategy adopted had helped in improving students' conceptual understanding.

4. Students enjoyed laboratory activities and the experiences resulted in high performance in studying measurement in physics. The analysis suggested that practical activities in measurement in physics had a significant impact on student performance, as evidenced by the higher mean and standard deviation of the post-test scores (29.7, SD=7.2) compared to the pre-test scores (13.6, SD = 4.4), and the significant results of the paired sample t-test (0.010<0.05, 16.13>1.68).

5.3 Conclusion

The study concluded that practical activities helped to enhance the process skills, conceptual understanding and performance of students in measurement in physics.

1. The students' level of acquisition of the requisite scientific process skills needed for science practical was greatly enhanced during the implementation of the intervention strategies of the study. Following these stated achievements, the pre-conceptual skills of students towards the study of measurement was evidently improved.
2. The use of practical activities aimed at allowing students apply concepts into real-life situation as suggested by Sawyer (2008). Antwi et al (2021) also reported that practical work was a significant tool for developing students' scientific knowledge and habit of mind which concurs with the finding that practical activities contribute to increased ability to conceptual understanding. Based on the findings, a strong case can be made on the positive or improved effect of practical activities on the conceptual understanding of students in measurement in physics.
3. There is an indication to the fact that students' average academic achievement after the inculcation of practical work was higher than the students' average academic

performance before the introduction of frequent practical work. This study has revealed that practical activity is more effective in the teaching and learning process of some selected topics in physics. The advantage of a practical activities is to create and enhance students' motivation, interest, and achievement. This definitely can bring about more effective learning. This study adds to the global discussion on the use of practical activities to enhance performance in physics.

4. Generally, it can be concluded that practical activities engage students actively in the learning process, promote open mindedness, help students acquire process skills, aids better conceptual understanding among students and promote positive performance towards measurement in physics.

5.4 Recommendations

Based on the findings and the conclusions drawn from the research, the following recommendations have been made:

1. Measurement in physics should be treated with much attention at Kaleo Senior High and Technical School as it serves as the foundation to which all aspect of physics is built upon.

2. Teachers at Kaleo Senior High School should involve students in series of practical activities in the learning of physics since it enhances their process skills, conceptual understanding and performance.

3. The school Head should make sure there are provisions of laboratory consumables to sustain regular practical activities in Kaleo Senior High and Technical School.

5.5 Suggestions for Further Research

Base on the findings and limitations of the study, the following suggestions have been made for further research:

1. The study should be conducted in all aspects of physics topics to find out how practical activities will improve student achievement.
2. A study should be conducted to investigate how practical activities in physics facilitates the development of student thinking.
3. A study should be conducted to determine the differences between the performances of students from less endowed schools and those from highly endowed schools in measurement in physics.
4. Science education division of Ghana Education Service should organise regular in-service training for physics teachers on how to carry out most of the physics practical since most of them do not have the requisite process skills.
5. Workshops, seminars and conferences on the importance of laboratory activities should be organised for physics teachers to enable them prepare and develop themselves towards improving the achievement of their students.

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APPENDIX A

OBSERVATIONAL CHECKLIST

Name of Observer: …………………………………………………………………………

Group Observed: …………………………………………………………………………

Date Observed: …………………………………………………………………………..

Statement **(What did you observe?)**	**Done Correctly**	**Not Done Correctly**
1. Students working collaboratively.		
2. Students identify an appropriate instrument for measuring.		
3. Students record least count of measuring instrument in use.		
4. Students identify zero error of measuring instrument in use.		
5. Students apply a correct standard unit of measurement.		
6. Students avoid parallax error when taking readings.		
7. Students read standard measures to describe the dimensions of the object in use.		
8. Students record appropriate reading on the measuring instrument in use.		
9. Students organise data and draw conclusions from it.		

10. Students properly handle the measuring instrument.		

Notes/Comments:

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APPENDIX B

LABORATORY TEST

Instruction: Answer all the questions below.

You are provided with the following regular solids and measuring instruments.

A = Wood Block

B = Cylindrical object

C = Cube

D = Spherical bob

E = Transparent object

F = Thin wire

G = Micrometre screw gauge

H = Vernier calliper

I = Triple beam balance

J = Metre rule

1. Measure the mass of the solids A, B, C, D, E and F. (6 marks)
2. Measure the length, breadth and height of objects A, C, and E (3 marks)
3. Measure the diameter of objects B, D, and F (3 marks)
4. What is the least count of objects G and H (2 marks)
5. State one function each of object’s G and H (2 marks)
6. State two precautions to avoid parallax error. (2 marks)

APPENDIX C

QUESTIONNAIRE FOR STUDENTS

Dear respondent,

The purpose of this questionnaire is to know about your skills and conceptual understanding on **Measurement in physics**. Your responses will be treated confidentially and will be used for research purposes only. No persons will be identified in any reports. Thank you for completing the questionnaire. Your participation will be acknowledged.

Please tick or provide a short statement where appropriate in the spaces provided below.

Section A: **Biodata**

1. Gender: Male [ ] Female [ ]
2. Age range (in years): ≤ 15 [ ] 16 – 18 [ ] 19 – 21 [ ] 22-24 [ ] 25- 27 [ ] 28 ≥ [ ]
3. Group: ……………………………………………………………………………………

Section B: **Pre-conceptual skills of students in Measurement in physics**

Statement	Strongly Agree (1)	Agree (2)	Uncertain (3)	Strongly disagree (4)	Disagree (5)
1. Can you identify an appropriate instrument for measuring an object?					
2. Can you apply a correct standard unit of measurement?					
3. Are you able to avoid parallax					

errors when taking readings?					
4. Can you use standard measures to describe the dimensions of an object?					
5. Can you differentiate between the length, breadth, and height of an object?					
6. Can you identify zero error in a measuring instrument?					
7. Can you find the least count of a measuring instrument?					
8. Can you record appropriate readings on a measuring instrument?					
9. Can you organise data and draw conclusions from it?					

Section C: **Student conceptual understanding of Measurement in Physics**

1. What determines the precision of a measurement?

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2. What is uncertainty in measurement?

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3. A student measures a distance several times. The reading lies between 49.8cm and 50.2cm. What is the best way of recording this?

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4. The number of significant figures in the measurement of 0.00807600cm is?

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5. For an answer to be complete, the units need to be specified. Why?

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6. What is least count error?

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7. How can least count error be reduced during measurement?

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8. Can you find the diameter of a thin wire of length 2m using a ruler? State the reason for your answer.

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9. What is the advantage of using the International System (SI) of units?

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10. What is the difference between precision and accuracy in measurement?

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APPENDIX D

STUDENT'S PRE-TEST AND POST-TEST

Name: ………………………………………………………………………………..

Class: ………………………………………………………………………………

Instruction: Answer all the following questions below:

1. What is measurement? 1mrk
2. Differentiate between precision and accuracy. 2mrks
3. Explain what is meant by least count of a measuring device. 1mrk
4. State the seven (7) basic quantities and their units. 7mrks
5. State and explain three types of error in measurement. 6mrks
6. Give three (3) measuring tools used in measuring length. 3mrks
7. Write down the least count of a vernier calliper and micrometre screw gauge 2mrks
8. Explain how to take reading using a tape measure. 3mrks
9. How is reading on the main scale of a micrometre taken. 5mrks
10. Explain how the vernier scale is used in taking readings from the vernier calliper. 5mrks
11. What is the S.I unit of Force and Power? 2mrks
12. List three instruments used for measuring mass. 3mrks
13. Briefly explain how to use a triple beam balance in taking measurement. 5mrks
14. Briefly explain how to use an electronic balance in taking measurement. 5mrks

APPENDIX E

LETTER OF INTRODUCTION

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF INTERGRATED SCIENCE EDUCATION
P. O. Box 25, Winneba, Ghana
ise@uew.edu.gh
+233 (020) 2041077

Our ref. No.: ISED/PG.1/Vol.1/35
Your ref. No.:

6th September, 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION
MR OWUSU, MICHAEL

We write to introduce, Mr Owusu is a MPhil. student of the Department of Science Education, University of Education, Winneba, who is conducting a research titled:

USING PRACTICAL ACTIVITIES TO IMPROVE SENIOR HIGH SCHOOL STUDENT'S SKILLS, CONCEPTUAL UNDERSTANDING AND PERFORMANCE ON MEASUREMENT IN PHYSICS

We would be very grateful if you could give the assistance required.

Thank you.

Yours faithfully,

MS. ALEXANDRA N. DOWUONA
CHIEF ADMINISTRATIVE ASSISTANT
For: HEAD OF DEPARTMENT

www.uew.edu.gh

APPENDIX F

RELIABILITY TEST

Notes

Syntax		RELIABILITY /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA.
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.05

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	83.3
	Excluded[a]	2	16.7
	Total	12	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.960	19

APPENDIX G

MARKING SCHEME FOR PRE-TEST AND POST TEST

1. Measurement is a technique for determining an object's qualities by comparing it to a particular quantity. **(1 mark)**
2. Precision is usually related to the random error distribution associated with a particular experiment or even with a particular type of experiment whilst accuracy is related to the existence of systematic errors. **(2 marks)**
3. Least count for a measuring instrument means the smallest value that can be measured using the instrument. **(1 mark)**
4.

Quantity	SI unit
Length	Metre
Mass	Kilogram
Time	Second
Electric current	Ampere
Temperature	Kelvin
Luminous intensity	Candela
Amount substance	Mole

(1 x 1 mark = 7marks)

5. i. Reading error: Reading Error refers to the uncertainties caused by the limitations of our measuring equipment and/or our own limitations at the time of measurement (for example, our reaction time while starting or stopping a stopwatch). This does not refer to any mistakes you may make while taking the measurements.

ii. Random Error: It refers to the spread in the values of a physical quantity from one measurement of the quantity to the next, caused by random fluctuations in the measured value.

iii. Systematic Error: It refers to an error which is present for every measurement of a given quantity; it may be caused by a bias on the part of the experimenter, a mis-calibrated or even faulty measuring instrument. **(1 x 2marks = 6marks)**

6. a. Ruler

   b. Tape measure

   c. Vernier calliper **(1 x 1 mark = 3marks)**

7. Vernier calliper - 0.1mm

   Micrometre screw gauge – 0.01mm **(1 x 1 mark = 2marks)**

8. Catch the hooked end on one side of the object you are measuring. Stretch the tape across your object. Take a reading directly from the tape. Use the lock switch to keep the tape at the same length. **(3marks)**

9. The main scale of a micrometre is calibrated in millimetres. The calibrations of the main scale of micrometre screw gauge vary depending on the range of measurement that the micrometre screw gauges are meant to measure. **(5 marks)**

10. Unlock the lock screw and press the thumb screw down. Open the jaws. Close the jaws around the object you want to measure or, for inside measurements open them until the fill the gap you wish to measure, or insert the depth rod into the hole you wish to measure. Tighten the lock screw so that the jaws do not move. Now read the scale. **(5marks)**

11. Force – Newton

    Power – Watt **(1 x1 mark = 2 marks)**

12. a. Electronic balance

    b. Triple beam balance

    c. Top pan balance **(1 x 1 mark = 3marks)**

13. With the pan empty, transport all three riders on the three beams to the far left. Check the pointer and scale to make sure they are both zero. If it doesn't, calibrate the scale by twisting the adjustment knob until it reads zero. After calibration, centre the object to be measured on the pan. The pointer will be moved away from zero. Slide the 100g rider to the left slowly from notch to notch, until the pointer drops below the zero mark. At this point move the rider back a notch. For example, if your object weighs 485g, then the pointer will drop below zero when the rider is put on the notch representing 500g. So, you will have to slide it back to the 400g notch. Now, move the 10g rider from notch to notch as you did with the 100g notch until the pointer falls below zero, at which point you must move it back a notch. If your object weighs 485g, your 10g rider will go below zero at the 90g notch once again. After that, you must return it to the 80g notch. Finally, carefully move the 1g rider along its beam until the pointer coincides with zero. Take the total of all the three numbers indicated by the positions of the three riders to get the mass of the object on the pan. **(5marks)**

14. Place the electronic balance on a flat surface. Press the ON button and wait for the balance to show zeroes on the digital screen. Use a container for your object to be massed. (Never place directly on the balance). Record the mass of the empty container (M_1). Carefully add the substance to the container. Ideally this is done with the container still on the platform of the balance. Record the mass as indicated by the digital display(M_2). Subtract the two masses recorded (M_2- M_1). **(5marks)**

TOTAL MARKS = 20 MARKS

APPENDIX H

MARKING SCHEME FOR LABORATORY TEST

1. A - 32g

   B - 27g

   C - 40g

   D - 24g

   F - 3.74g **(1x ½ mark each = 2 ½ marks)**

2. Object A

   Length - 14.5cm

   Breadth – 5.1cm

   Height – 3.2 cm

   Object C

   Length - 6.0 cm

   Breadth – 6.0 cm

   Height – 6.0 cm

   Object E

   Length – 5.6 cm

   Breadth - 4.1 cm

   Height – 3.0 cm **(1 x ½ mark each = 4 ½ marks)**

3. Object B = 125mm

   Object D = 102 mm

   Object F = 0.35 mm **(1 x ½ mark each = 1 ½ marks)**

4. Object G = 0.01mm

   Object H = 0.1mm **(1 x ½ mark each = 1mark)**

5. Object G: For measuring exactly the diameter of a thin wire or the width of a sheet of metal.

   Object H: To measure the internal and external dimensions or distance extremely accurately. **(1 x 1 ½ marks = 3marks)**

6. A. Take the average of readings

   B. Orientation of eyes should be in a straight line **(1 x 1 mark each = 2 marks)**

TOTAL MARKS = 15 MARKS

NB: ALL MEASURED VALUES ARE NOT DRAWN TO SCALE

½ MARK FOR NICE PRESENTATION OF ANSWERS