

**THE ATTITUDES OF PRE-SERVICE TEACHERS TOWARDS THE USE OF
EXPERIMENTS IN TEACHING AND LEARNING SCIENCE**

BY

SHONISANI GRACE MUKWEVHO

(11635289)

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SUPERVISOR (Dr SJM KAHERU)

CO-SUPERVISOR (.....)

Signatures: student

Date...2025 02 12.....

Supervisor

Date.....2025 02 12.....

2025

DECLARATION

I declare that **“The Attitudes of Pre-Service Teachers Towards the Use of Experiments in Teaching and Learning Science”** is my work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other institution.

Mukwevho Shonisani Grace

28/01/2025

DECLARATION OF PLAGIARISM

I, Mukwevho Shonisani Grace, hereby declare that this mini dissertation entitled " **The Attitudes of Pre-Service Teachers Towards the Use of Experiments in Teaching and Learning Science** " is my original work. Every source that has been cited or used has been properly referenced. I certify that I have not submitted this work to any other university to receive an academic degree, and I am aware of the consequences of plagiarism in accordance with the rules of the University.

I further declare that:

- I have read and understood the University's policy on plagiarism.
- This dissertation complies with the academic integrity guidelines provided by the institution.
- Any work that is not my own has been clearly referenced and acknowledged.

Signed:  _____

Date: 28/01/2025

DEDICATION

This mini dissertation is dedicated to my daughter Melindah and my sisters, whose unwavering support, guidance, and encouragement have been a source of inspiration throughout my academic journey.

To my parents, thank you for your unconditional love and belief in my abilities. Your sacrifices and support have made this achievement possible.

To my supervisor Dr SJM Kaheru, your wisdom and guidance have been invaluable in shaping my academic and personal growth.

Lastly, to all those who share a passion for science subjects, may this work serve as a small contribution to our shared pursuit of knowledge and understanding.

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ABSTRACT

This study examined the attitude of pre-service teachers towards the use of experiments at a university in South Africa. This study employed a quantitative research design to investigate the attitudes of a sample of 82 pre-service teachers toward the use of

experiments in science education. The participants were chosen through stratified random sampling. In a stratified random sample, the population was split into gender-based groups that are mutually exclusive, and random samples were taken from each category. The population comprised all undergraduate pre-service science teachers. All 2nd-year pre-service science teachers made up the study sample size (36 males and 46 females, making a total of 82).

The study utilised experiments, survey administration, and questionnaires to gather data on pre-service teachers' attitudes and experiences related to experiments in science education. The data was collected using Google Forms and shared via WhatsApp. The aim was to understand the occurrence of positive and negative attitudes, identify potential patterns, and assess the impact of demographic variables such as gender. The questionnaires were designed to elicit responses regarding pre-service teachers' attitudes, perceptions, and experiences related to experiments in science education. These attitudes were measured and analysed quantitatively using IBM-SPSS, with a focus on understanding the pre-service science teachers attitudes towards the use of experiments by identifying potential patterns and assessing the impact of demographic variables.

Virtual or computer laboratory simulations are computer-based tools with wide application possibilities in scientific areas. Virtual laboratories include students doing experiments online, and they require input data to begin the tests. Real laboratory experiments involve tasks that are carried out in the laboratory using a lab manual. Students acquire data in this type of experiment by taking measurements or making observations. Additionally, the lab manual was provided to assist with the carrying out of the experiment. The statistical analysis method used is called inferential statistics. This type of method was used to measure differences between groups (between males and females), assess relationships between variables and test hypotheses. IBM-SPSS version 28 for Windows was used to analyse data that were collected using google form on a weekly basis. Most of the pre-service science teachers shows positive attitudes towards the use of experiments in science education. This confirms that majority of pre-service science teachers identify

experiments as an effective teaching tool to make learners understand the curriculum and improve student engagement.

According to the findings, female pre-service teachers showed a slightly higher positive attitudes towards the use of experiments than male pre-service teachers. Males only shows the confidence of able to conduct experiments independently and with less help from the demonstrator. Results showed that gender does not significantly influence attitudes towards experimental methods in science education among pre-service teachers, indicating the importance of using lab manuals in scientific areas. The study encourages the importance of having practical science experiments during the teacher education programs to foster positive attitudes and improve teaching effectively.

KEY CONCEPTS: Pre-service teacher, Experiments, Attitudes, Science teacher



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ACRONYMS

FCPs – Future Career Perspectives

SPSS – Statistical Package for the Social Sciences

SD – Standard Deviation

SE – Standard Error

CI – Confidence Interval

IQR – Interquartile Range

H_0 – Null Hypothesis

H_1 – Alternative Hypothesis

Z – Z-score

p – p-value

UAE- United Arab Emirates UAE

TPB – Theory of Planned Behaviour

ANOVA – Analysis of Variance

IBM – International Business Machines

VR-Virtual Reality

CHAPTER 1: ORIENTATION TO THE STUDY

1. INTRODUCTION AND BACKGROUND

Science education is an important component of a well-rounded education because it provides students with the information and skills they need to comprehend and engage in the world of science and technology. Science plays an important role in making the student understand the natural world. Experiments allow students to explore science through practical teaching, or by performing experiments. According to Kazempour and Sadler (2015, p.250), science concepts need to be “taught” or “shown” to students, and science experiments are meant to confirm teacher instruction and textbook explanations and to make science learning fun. Experiments have become a powerful tool for improving the effectiveness of science education, as they engage students in hands-on, interactive experiences that promote critical thinking, problem-solving, and a deeper understanding of scientific concepts (Kazempour & Sadler, 2015, p.250). Pre-service science teachers, who are currently training to become educators, play a significant role in shaping the future of science education (Gracia et al., 2019, p. 1756). Their attitudes and beliefs about teaching methodologies, including experiments, are central to the transformation of science education (Fan & Geelan, 2013, p.130). Understanding the transformative impact of experiments on pre-service science teachers is vital to improving science education at all levels.

Pre-service teachers' attitudes regarding the use of experiments can also have an impact on their teaching approaches. Those who regard experiments as important tools are more likely to employ them successfully, hence improving the quality of scientific education provided to their learners (Tomas et al, 2017). Those with negative views, on the other hand, may neglect tests, missing out on the benefits they provide. According to Kula (2022), examining these attitudes helps the larger discussion of scientific education by underlining the necessity of encouraging creativity, discovery, and experiential learning in the science classroom.

Challenges faced by pre-service teachers when integrating experiments into their teaching practices include lack of resources, time constraints, and classroom management issues. Recognising these obstacles provides an opportunity to develop solutions and support systems that empower pre-service teachers to effectively use experiments in their classrooms. Experiencing experiments during teacher training can influence the attitudes of pre-service science teachers in various ways, such as sensitive confidence in their subject matter knowledge and increased excitement for teaching. These changes can have a great impact on the effectiveness of their future classrooms. Laboratory activities provide students with cognitive, emotional, and psychomotor abilities such as planning experiments and comprehending how theories develop from experiments (Harman, 2016). Experiments can also shape pre-service teachers' perspectives on teaching methods, the value of hands-on learning, and the importance of fostering scientific curiosity among their learners.

Lee  (2018) found that physics students who participated in practical work outperformed those taught using the traditional teaching style. If a practical assignment is effectively prepared and expertly presented by the teacher, it may have an impact on students' learning process. Gericke  (2023) stated that the most relevant idea for collecting the recognized phenomena of interest in this investigation is laboratory work. According to Agustian and Seery (2017), laboratory instruction became a separate and independent component of education, with an emphasis aimed to teach students about how to "do science"(p. 518). So, the key objective of laboratory instruction is to immerse students in the scientific method by offering them opportunities to actively engage with materials and apparatus while they are performing experiments.



In South African science education is always experiencing challenges such as, lack of laboratory resources and lack of laboratory access (Reference). Pre-service teachers have a critical role in addressing those challenges in various educational settings since they are trained to become future teachers. They must address those challenges by incorporating effective experimental methods into the future classes (Reference). Their perspectives on the use of experiments in teaching can greatly impact their instructional

approaches and, consequently, the learning experiences of their students (Gracia, Rodríguez, & Pedrajas, 2019).

There is a long-running discussion about the role of laboratory work in science education that stretches back to decades and demonstrates the belief and interest of teachers and researchers all around the world in the usefulness of laboratory work for understanding science (Harman et al, 2016). According to Frod (2013), learning by doing is more effective than learning by listening or reading, and when students learn by doing (using information to solve a problem), they are more likely to remember what they have learned, as well as process the information they are receiving and reflect on how they learned. Laboratories are one of the most common locations for conducting experiments. According to Harman *et al.* (2016) p12, the statement "I heard, but I forgot." I noticed and remembered. The words "I did, and I understood" emphasize the importance of laboratories in science education. From this point of view, a laboratory is an atmosphere in which students learn through hands-on activities, living, and receiving first-hand tangible experiences (Harman *et al.* 2016).

Science teachers' attitudes towards experiments are of academic interest and practical implications. "Understanding these attitudes can help modify curricula and provide necessary skills for successful teaching. Investigating difficulties and barriers in integrating experiments into curricula can help future educators prepare for the complex process. A positive attitude can inspire curiosity, critical thinking, and passion for science among the next generation" (Blatti et al. 2018, p. 2857). This study aims to explore, understand, and shed light on pre-service teachers' attitudes towards experiments in teaching and learning science, contributing to the ongoing dialogue on enhancing the effectiveness of science education and inspiring future generations to become scientifically literate, curious, and engaged citizens.

2. STATEMENT OF THE PROBLEM

Science education is an important part of modern education because it prepares students to understand and interact with the scientific world around them (Aydin, 2021). Science foster curiosity and promote critical thinking by developing student problem thinking skills.

The use of experiments in teaching and learning science is an important aspect of science education. However, the attitudes of pre-service teachers towards the use of experiments in teaching and learning science are not well understood. The main problem is that pre-service teachers' beliefs and views about the use of experiments in scientific education can have a major impact on the quality of science education. The successful use of experiments in science teaching and learning is widely acknowledged as an important tool for improving students' scientific literacy, critical thinking, and problem-solving abilities (Sutiani, et al., 2021). Pre-service teachers, hold the key to the successful implementation of experiments in scientific classrooms. However, their attitudes and beliefs about the use of experiments in scientific education can have an important effect on the quality of science education. Gender-based differences in science education, particularly in the use of experiments, have been identified as a significant factor influencing the attitudes and enjoyment of science learning (References).

Attitudes and beliefs of pre-service teachers significantly influence their teaching practices, particularly in science education. These attitudes can either generate passion or delay their willingness to use experiments. Understanding these attitudes can help to modify teacher education programs and provide modified professional development opportunities. By recognising pre-service teachers' beliefs about experiments, educators can create more engaging and experiential learning experiences. Collaboration between scientists, teachers, and policymakers can develop confidence and commitment in science education.

It is necessary to investigate the factors that impact pre-service teachers' attitudes on the use of experiments in scientific education. The problem is around determining if pre-service teachers' prior experiences, training in teacher education programs, or other external variables significantly impact their views. The effective integration of experiments into science education requires pre-service teachers to not only have positive attitudes but also the skills and knowledge to implement experiments successfully. The problem arises when pre-service teachers face challenges in incorporating experiments into their teaching practices, including resource limitations, time constraints, or a lack of confidence in their own experimental abilities.

Pre-service teachers' attitudes regarding experiments have a direct influence on the quality of scientific education they deliver to their future learners (Harman et al., 2016). The issue is determining how pre-service teachers' attitudes affect their students' engagement, motivation, and knowledge of science subjects, and hence their development of scientific literacy. Teacher education programs are critical in training pre-service teachers for careers as science educators. This study concerns the effectiveness of these programs in establishing positive attitudes and providing pre-service teachers with the required training and tools to include experiments in their teaching approaches.

Despite the critical role that pre-service teachers play in the development of scientific education, a detailed study of their attitude about the use of experiments is limited. The issue is a lack of understanding of these attitudes and their implications for scientific education. This study aims to address these problems by investigating pre-service teachers' attitudes regarding the use of experiments in scientific teaching and learning. It aims to contribute to the improvement of science teaching practices as well as the scientific literacy of future generations by identifying the factors that shape these attitudes, understanding the challenges pre-service teachers face in implementing experiments and recognizing the broader implications for science education. Furthermore, gaps in exposure, confidence, or pedagogical views that need to be addressed in teacher training programs may be indicated by gender variations in attitudes toward experiments. By identifying these attitudes, the study contributes to improving science education training, ensuring that future teachers are well-equipped to provide effective, engaging, and well-balanced experimental learning experiences for students.

3. RESEARCH QUESTIONS

- To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?
- To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?

- What factors such as pedagogical training or resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?

4. RESEARCH HYPOTHESIS

The following hypotheses were formulated by the researcher to guide this study.

HO_1 : There is no significant association between pre-service teachers' beliefs about the impact of conducting experiments and the development of scientific skills and attitudes.

HA_1 : There is a significant association between pre-service teachers' beliefs about the impact of conducting experiments and the development of scientific skills and attitudes.

HO_2 : There is no significant association between pre-service teachers' beliefs about considering gender-related attitudes and the choice between real or simulated experiments in science education programs.

HA_2 : There is a significant association between pre-service teachers' beliefs about considering gender-related attitudes and the choice between real or simulated experiments in science education programs.

HO_3 : Factors such as pedagogical training or resource availability do not significantly influence the frequency of pre-service teachers' use of simulations or real experiments at high school education level.

HA_3 : Factors such as pedagogical training or resource availability significantly influence the frequency of pre-service teachers' use of simulations or real experiments at high school education level.

5. RESEARCH AIM AND OBJECTIVES

The aim of the study is to investigate and understand the attitudes held by pre-service teachers regarding the incorporation of laboratory experiments into their teaching practices.

- To evaluate the extent to which pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes.
- To examine whether pre-service teachers believe that science education programs should consider gender-related attitudes when deciding on the use of real or simulated experiments.
- Investigate factors that may influence the frequency of pre-service teachers' use of simulations or real experiments in high school-level education.

6. DEFINITION OF CONCEPTS

Pre-service-> The Oxford Dictionary (1989) defines "pre-service" as "the period before a person's entry into a job that requires training." In the context of education, "pre-service" refers to the time before a teacher begins working and receiving training. It is one of two stages of teacher professional development, the other being in-service. Gaining a fundamental understanding of teaching and the principles that guide the profession, theoretical knowledge, technical skills, psychology, and lesson preparation are all part of the pre-service phase of professional development.

Experiments-> An experiment is scientific research in which a hypothesis is tested (Mcleod, 2023). In an experiment, an independent variable (the cause) is changed, and the dependent variable (the effect) is measured; any extraneous factors are controlled. The fact that experiments should be objective is a benefit. According to Mcleod (2023), the researcher's beliefs and opinions should not influence the findings of a study. This is beneficial since it makes the data more valid and less biased.

Attitude-> In psychology, an attitude is a collection of feelings, beliefs, and actions toward a certain object, person, thing, or event. According to Chery (2023), attitudes are frequently the outcome of experience or upbringing. They can have a strong impact on behavior and how individuals behave in various situations. While attitudes endure, they

may also shift. Attitude is composed of cognitive, emotional, and behavioral components, which include ideas, feelings, and behaviors.

Science Education-> “Science education is a multifaceted field that encompasses the teaching and learning of various scientific disciplines, aiming to develop students' understanding, skills, and scientific literacy. It includes subjects such as biology, chemistry, physics, and environmental science. Science education is vital for equipping individuals with the knowledge and critical thinking skills needed to engage with scientific concepts and make informed decisions in a science-based society” (NSTA2022).

7. SIGNIFICANCE OF THE STUDY

The significance of this study lies in its potential to inform teacher training, curriculum development, and policy formulation in science education. By addressing the objectives, the research has the capacity to improve the quality of science education, enhance teacher preparedness, and foster a more inclusive and engaging environment for both pre-service teachers and their future learners. This research will also help lecturers better understand how scientific experiments affect the attitudes of pre-service science students, which will lead to the creation of more successful teaching methods. If positive attitudes are linked to hands-on learning experiences, lecturers may add more experiments into their educational programs to improve student engagement and learning results. Science experiments can make learning more interesting and participatory. If the study finds a link between scientific experiments and improved attitudes, lecturers will be able to create classes that cater for different learning styles and encourage active engagement among students in the future.

This study can give insight into whether participating in science activities during schooling improves the confidence of pre-service science teachers. Positive experiment experiences may motivate pre-service science teachers to conduct experiments with learners in the future. Favourable attitudes regarding scientific experiments may lead to more favourable attitudes toward science learning in general. This can have long-term consequences for students' overall academic achievement and future learning objectives.

Understanding how science experiments affect attitudes can help the area of educational development. It can give insights into how students' cognitive and emotional domains are influenced by hands-on experiences, ultimately leading to the creation of educational interventions that promote attitudes and motivation.

Scientific experiments will have a good influence on students' attitudes; therefore, teacher education programs should highlight the necessity of implementing hands-on learning experiences in scientific teaching. This will assist and equip future educators to build interesting and successful learning experiences in the classroom. The research will emphasize the importance of hands-on education in boosting not only academic but also personal and social development. Positive attitudes about science will help pre-service science teachers receive a well-rounded education. In this situation, the research will improve student attitudes and the educational experience for future generations.

1.8 STRUCTURE OF THE RESEARCH PROJECT

You also need to include the structure of the dissertation

Research activity	April-2023	Aug 2023	Sep 2023	Oct-Nov 2023	Feb 2024	May 2024	Sep
Chapter 1: Introduction to the study (Proposal)	First draft of the research proposal	Sending proposal to the SHDC for consideration	Feedback from SHDC	editing proposal and sending it back to the SHDC	Cleared to apply for ethical clearance.		Ethical Clearance completed
Chapter 2: Literature review		-Collecting research articles, and starting with literature review		Sending Chapter 2 to my supervisor			
Chapter 3: Research design and methodology				Starting with Chapter 3		Sending Chapter 3 to my supervisor	
Chapter 4: Data presentation and analysis							Start collecting data and distribution questionnaires.
Chapter 5: Conclusion and Recommendations							

CHAPTER 2: LITERATURE REVIEW

1. INTRODUCTION

This chapter focuses more on the literature review on the effects of experiments on pre-service science teachers' attitudes. It provides a clear understanding of different authors' perspectives and criticisms. A literature review is a research strategy incorporating current information, meaningful discoveries, and theoretical and methodological commitments to a specific theme. It analyzes what different scholars have found, revealing main themes, methodologies, thoughts, discoveries, translations, problems, potential predicaments, and discussions between different writers. According to Rampean et al (2021), experiments are widely considered adequate to enhance students' understanding of scientific concepts and processes, developing their inquiry skills and scientific attitudes. However, there is a need for more agreement on how these attitudes affect pre-service science teachers, who are expected to design and implement experiments in their future classrooms.

This literature review explores the impact of experiments on pre-service science teachers' attitudes toward experiments and science teaching. Science education has undergone a transformative shift in recent years, with a growing emphasis on experiential and inquiry-based learning. A pivotal aspect of this transformation is the integration of experiments as a powerful pedagogical tool. Pre-service teachers, who are in the process of becoming educators, play a central role in shaping the future of science education (Tatar., 2015). This literature review delves into the multifaceted aspects of pre-service teachers' attitudes towards the use of experiments in teaching and learning science. It explores the existing knowledge base, identifies key factors that influence these attitudes, and examines the implications of these attitudes on science education. However, there has to be a standpoint based on research, demonstrating how these attitudes affect pre-service science teachers, who are expected to design and implement experiments in their future classrooms.

2. THEORETICAL FRAMEWORK

Constructivist learning theory served as my theoretical framework. According to this concept, students build their own knowledge and understanding by actively engaging with their surroundings and life experiences. Utilizing this idea, laboratory-based activities that offered chances for inquiry, investigation, discovery, and reflection were created with the goal of improving students' attitudes toward science. I measured student attitudes along four dimensions using the attitude-to-science paradigm developed by (Osborne, 2003) pleasure of scientific classes, relatability of scientists, interest in science as a profession, and relevance of science. I utilized questionnaires to gather quantitative data from the students, and then I used statistical techniques to compare the attitudes. I will use questionnaires to get quantitative data from pre-service teachers. These questions are built in Google Forms, and the link will be sent to a WhatsApp group of pre-service science instructors.

Attitudes are described as a degree of liking for an item or circumstance, and teachers may demonstrate different attitudes toward teaching and learning in the educational system (Lacruz P et al., 2021.). There is a lack of conceptual clarity in the field of teacher education research and educational sciences when it comes to properly describing what we mean by "attitudes." When it comes to research on teacher attitudes, teachers are sometimes used interchangeably with views or subjective theories, and conceptual clarity is frequently required. Teacher attitudes are important for a teacher's well-being because when a teacher's views about teaching and learning are consistent with their activities, they report a greater degree of satisfaction (Beck *et al.*, 2015). However, preservice teachers, in particular, who appear to face disagreeable attitudes and practices during their first in-service experiences in schools, may confront inconsistent attitudes and practices. In this paradigm, the so-called scientific method of study (experimental) is central, and an objective epistemology is assumed (Kivunja & Kuyini, 2017).

Attitudes matter in scientific education because they impact students' interest, motivation, engagement, and accomplishment (Osborne, 2003). There is, however, no agreement on how to assess or modify students' attitudes about science. The Theory of Planned

Behaviour (TPB) is one of the key theoretical approaches that has been utilised to investigate students' attitudes (Ajzen, 1991). According to TPB, attitudes, together with subjective standards and perceived behavioural control, are three drivers of behavioural intentions. It is considered that behavioral intentions determine actual conduct. This indicates that researchers who work within the dimensions of this paradigm view the world through the perspective of a one-way mirror (Healy & Perry, 2000). The researcher using this paradigm would normally use a logical approach, collecting data quantitatively and presenting the results as value-free and objective.

Attitudes, defined as behavioural beliefs and normative beliefs, play a crucial role in shaping students' intentions and behaviour towards science. TPB, a widely used theory, has been used to investigate the impact of experiments on pre-service science teachers' attitudes towards scientific instruction. However, TPB has been criticized for its disregard for emotions, values, identity, and context. This research aims to explore alternative theoretical frameworks that can better explain the complex and dynamic character of pre-service science teachers' attitudes towards scientific education. By examining attitudes, researchers can better understand how they impact behaviour and improve the quality of science education (Ajzen, 1991).

Attitudes, as per the Theory of Planned Behaviour (TPB), are influenced by behavioural beliefs, normative beliefs, and control beliefs. These factors influence one's intention to perform a behaviour, which in turn influences their actual behaviour. TPB suggests that changing students' attitudes can alter their intentions and behaviour towards science. This study seeks to explore alternative theoretical frameworks to better understand the dynamic nature of pre-service science teachers' attitudes towards science teaching.

3. EMPIRICAL LITERATURE

3.1. Definition of attitudes towards the use of experimental learning

“Behavioural responses to experiments shape scientific self-efficacy, influenced by social factors and personal characteristics, highlighting the complex nature of teachers' attitudes towards science (Ajay, 2019). A multi-case study will be designed to examine changes in pre-service teacher's beliefs, attitudes, and self-efficacy connected with participation in a

scientific methodology course and variables influencing these changes and interrelationships across the three categories (Kazempour, 2016). Kapici (2020) found that enhancing middle school students' attitudes toward scientific laboratory work may not be as beneficial as using virtual laboratory settings alone or in combination with hands-on laboratories. Virtual and hands-on laboratories are equally helpful for forming science attitudes, with virtual laboratories having a modest edge in some areas.

Attitudes about experiments significantly impact the professional development of science teachers in pre-service. Pre-service science teachers who embrace experiments will be more likely to develop into capable, passionate teachers who can encourage learners to develop a scientific understanding and career interest in science (Delello, 2014). However, the study's limitations on the number of participants and the scope of the studies, as well as the researcher's inability to make any conclusions from the manner the interviews will be performed and remain unexplored.

3.2. The Importance of Pre-Service Teachers' Attitudes

The attitudes of pre-service teachers toward the use of experiments in scientific education are important for many different reasons which have been supported by research and educational experience. Attitudes of pre-service teachers frequently serve as prior generations to their teaching methods. Pre-service teachers who have a favourable attitude about the utilization of experiments are more likely to successfully include experiments into their classroom education. The combination of mindset and practice can result in more interesting and successful educational experiences (Karsli et al., 2010). These attitudes can influence how a teacher approaches curriculum preparation, teaching methods, and assessment processes, all of which can improve students' learning experiences. The attitudes of pre-service teachers towards experiments can have a direct impact on student learning outcomes. When pre-service teachers have positive attitudes towards the use of experiments, they are more inclined to use these hands-on, experiential methods in their teaching. Students, in turn, often respond positively to such active learning experiences, which can enhance their engagement, motivation, and comprehension of scientific concepts (Anderson, 2016). When pre-service instructors have unfavourable views toward experiments or are afraid to employ them, students may

miss out on the benefits of active learning, thus hurting their learning experiences (Akerson *et al.*, 2009). In science education, pre-service teachers' attitudes serve as the connection between theory and practice. Positive attitudes toward experiments can lead to the effective implementation of these experiential approaches in the classroom, resulting in better student engagement and better understanding of scientific subjects.

3.3. Importance of experiments in science education

Pre-service teachers use the concept of science and its characteristics to explain the significance of laboratories in scientific education. The investigation of pre-service teachers' responses in the "Domains of Learning" category revealed that their focus was on cognitive abilities (Harman *et al.* 2016). However, cognitive abilities must be supported by psychomotor and emotional abilities. Pre-service teachers touched on emotional achievement as well, suggesting that they did not regard laboratories as purely educational environments.

Experiments are important in science education because of their many effects on students' learning and comprehension of scientific topics. Experiments engage students in active learning by allowing them to interact with materials, equipment, and concepts firsthand. This hands-on approach improves their comprehension by allowing students to experience scientific phenomena (Chen *et al.*, 2020). Experiments give concrete proof of abstract scientific theories and notions. When students witness experimental results that match what they have studied in theory, it strengthens their knowledge and trust in those concepts. Experimental design and execution need critical thinking abilities. Students must develop hypotheses, organize methods, observe, evaluate data, and draw conclusions. This approach develops analytical thinking and problem-solving skills that are useful both within and outside of science.

3.4. Academic improvement

In the current study, as pre-service teachers' overall academic success improves, so do their judgments of teaching self-efficacy, teaching attitudes, and teaching motivation (Kula, 2022). As pre-service teachers' average overall academic achievement rises, so does their efficacy for student engagement, instructional tactics, and classroom

management. In this setting, individuals who excel academically in teacher training programs in Turkey may also have significant emotional traits associated with teaching. It should not be disregarded that boosting subject performance in the teacher training process can help pre-service teachers have favourable teaching impressions. The inclination of pre-service teachers to pursue the teaching profession influences their judgments of teaching self-efficacy, teaching attitudes, and teaching motives (Kula, 2022).

This finding indicates that pre-service teachers' willingness to enter the teaching profession is essential in affecting their beliefs, attitudes, and motives toward teaching self-efficacy. Various research findings also confirmed that pre-service teachers who freely chose the department they studied and intended to teach had strong self-efficacy, attitude, and motivation for teaching (Gok & Atalay Kabasakal, 2019). In this regard, whether individuals wish to teach might be identified as a significant consideration for selecting students for teacher training faculties. There is a substantial association between pre-service teachers' ideas about teaching self-efficacy, attitudes toward teaching, and levels of teaching motivation.

3.5. Practical work in science education

The aims of practical work are to increase students' comprehension, strengthen their problem-solving abilities, and comprehend the nature of science through emulating scientists' behaviours. Tsakeni (2018) investigated physical science learners' access to successful practical practice in two South African high schools. The findings demonstrated that a lack of practical work resulted in underestimating practical work in physical science courses, and hence learners. Tsakeni (2018), stated that due to the high expectations associated with studying physical sciences, limiting access led to a social justice agenda. Tsakeni (2018) advocated for practical work to be supported through evaluation procedures and instructional leadership tools.

This research aims to contribute to the practical work of science topics by putting light on student participation as an important component of the teaching and learning process. If students are to completely profit from science subjects, their goals must be made clear to them. According to Zuhrieh et al. (2019), students would consider practical work as just

a diversion from the monotony of speaking, listening, and writing. As a result, hands-on learning is critical to the development of students' knowledge and abilities through the integration of practice and theory. Adopting practical work plans to assist teachers in local United Arab Emirates (UAE, 2021) schools teach numerous topics in the scientific curriculum by involving students in the learning process. Many schools might improve their scientific curriculum by including practical work with theoretical information taught through traditional means (Zuhrieh, et al., 2019).

Due to a lack of practical work in science education, students may face the challenge of developing specialized abilities in operating scientific gadgets and equipment in the laboratory. Students have difficulty handling and controlling laboratory equipment skilfully, according to scholarly works (Fadzil et al., 2017; Tesfamariam et al., 2015). The development of manipulating abilities is an important objective of practical work. Continuous exposure to practical work through experimentation in several topic areas is one of the most effective strategies for building manipulative abilities. Students' incapacity to develop manipulating abilities might have a major impact on their ability to acquire other necessary laboratory skills such as data recording and reporting. Furthermore, students who are proficient in manipulative skills will have better opportunities to focus on the development of science process skills in inquiry-type practical work (Darmaji et al., 2019). As a result, it is necessary to increase the practical work experiences of preservice science teachers to provide them with manipulative skills and increase the potential to use them in their future classes.

3.6. Studying how gender and scientific interest relate

According to Kang et al. (2019), the knowledge gap on the primary stage of gender differences in career orientation in science and to further the understanding of how students' FCPs differ for male and female students during the transition to secondary school. The research focused on the relationships between students' professional perspectives and their interest in science, as well as gender variations in the following, scientific interests, and future career perspectives. The gender research was carried out using multiple-group structural equation modelling, and in one statistical model, students were divided into a male group and a female group (Kang et al., 2019).

Badri et al. (2016) focused on the connections between Future Career Plans (FCP) and interest-related categories such as attitudes towards science, extracurricular activities, science in school, or interest in science topics with 15-year-old students. The findings revealed a considerable gender gap between male and female students' identities in physics. Additionally, it was noted that physics identity strongly correlates with future profession choice and self-perceptions connected to physics. However, this identity was favourably connected with intrinsic pleasure like creating new things or learning new things but negatively correlated with future aspirations about personal time and people-related motivations. Additionally, these determinants of expected career outcomes decreased gender inequalities in physics identification in statistical models. In other words, it says that the impact of gender difference on future career expectations was lessened by including profession-related factors in the model.

3.7. How are Attitudes of Laboratory Experiments Defined and Measured?

a) Definition of attitudes towards experiments.

Attitudes towards experiments are complex and multidimensional constructs that reflect pre-service science teachers' cognitive, affective, and behavioral responses to experiments. The findings demonstrated that scientific self-efficacy was more significantly related to science accomplishment than curiosity, social importance of attitude toward science, and mixed attitude (Mao, 2021). People's attitudes about experiments are dynamic and diverse rather than rigid and uniform. Personal characteristics, past experiences, beliefs, expectations, emotions, motivation, curriculum, teaching, assessment, resources, culture, peers, mentors, or role models may all influence pre-service science teachers' views about experiments. As a result, it is critical to assess attitudes toward trials using valid and trustworthy tools to capture these dimensions and variances. The multi-case study was designed to examine changes in pre-service teachers beliefs, attitudes, and self-efficacy connected with participation in a scientific methodology course and variables influencing these changes and interrelationships across the three categories (Kazempour, 2016). This definition demonstrates how views about experiments are dynamic and diverse rather than rigid and homogenous. Pre-service science instructors may have various views about experiments depending on their

unique characteristics, past experiences, beliefs, expectations, emotions, motivation, curriculum, teaching, evaluation, resources, culture, peers, mentors, or role models. Therefore, assessing attitudes toward trials using accurate and trustworthy tools that consider these dimensions and differences is crucial.

According to Kapici (2020), enhancing middle school students' attitudes toward scientific laboratory work in all areas may not be as beneficial as using virtual laboratory settings alone or in combination with hands-on laboratories. Although this is only sometimes the case, it has been discovered that virtual laboratories can be advantageous to pre-service science students on their own. Based on the findings from the attitude questionnaire, both virtual and hands-on laboratories are similarly effective in shaping science attitudes, with virtual labs showing a slight advantage in certain aspects. The interview findings indicated more noticeable advantages for virtual laboratories or a mix of hands-on and virtual labs (Kapici et al., 2020, p. 544). This information demonstrates that attitudes about experiments significantly impact the professional development of science teachers in pre-service. Pre-service science teachers who embrace experiments are more likely to develop into capable, passionate teachers who can encourage learners to develop a scientific understanding and career interest in science. The study's limitations on the number of participants and the scope of the studies are among its shortcomings. The researcher was unable to make any conclusions from the manner the interviews were performed on the connection between students' academic achievement and attitudes toward science, which still has to be investigated (Kapici, 2020). Although there is no consensus on the definition of attitudes toward experiments, most authors agree that they are essential factors influencing pre-service science teachers' learning outcomes and teaching practices.

a) How is attitude measured?

The Test of Science-Related Attitudes (TOSRA) is widely used for measuring pre-service science instructors' attitudes toward experiments. It assesses seven aspects of attitudes toward science, including interest in a career in research, societal consequences of science, and attitudes toward scientific investigation. The TOSRA has been successfully used across various settings and demographics, including science instructors in training.

Although the efficacy metrics used in the research are described, a synthesis of study findings is not conducted. (Huang, 2021).

Attitude Toward Science Teaching Inventory (ASTI) is another technique used to measure attitudes, while others have used interviews, observations, or portfolios. You could also mention how some instruments have focused on general attitudes toward science or science teaching while others have focused on specific aspects of experiments such as design, implementation, or evaluation. The choice of instrument depends on the purpose and context of the study. However, using valid and reliable measures that capture the complexity and diversity of pre-service science teachers' attitudes toward experiments is essential.

This study uses observation to measure pre-service science teachers' attitudes, but studies have yet to be conducted to synthesize the results as per the effectiveness measures used in the included studies (Huang, 2021).

3.8. Factors That Influence Pre-Service Science Teachers' Attitudes Towards Experiments

a) Personal factors

Pre-service science teachers' attitudes towards experiments are influenced by their personal characteristics such as gender, age, academic background, prior experiences, beliefs, expectations, and emotions.

b) Gender

One of the personality traits that affects how pre-service science teachers feel about experiments is gender. The majority of women believe that science is challenging, and they might not understand it in the same way men do. However, because women appear to take everything they do seriously and science demands seriousness, men mistakenly believe that science is the domain of women. "Students that are interested in science hold different points of view on how gender equality is seen in that field. While some argue

that men and women have the same opportunities in science and that it simply depends on the scientific knowledge and abilities that an individual has obtained, others see gender inequities as being present” (Buenestado-Fernández, 2023).

Some research focuses more on the outcomes of science, putting laboratory trials into practice. The results of this study will then close that gap and discuss how experiments affect pre-service science instructors' attitudes. The survey concentrates more on attitudes among men, women, and a combination of men and women. Both male and female pre-service teachers had much greater stress levels than the general population, according to (Geng., et al, 2022). Male pre-service teachers were shown to have considerably greater stress levels than female pre-service teachers once more. Other research, however, has not discovered any appreciable variations in pre-service science instructors' views about experiments based on gender (Kazempour, 2016). This may be the case because gender is not a fixed factor but a dynamic factor, and it interacts with other factors like age or types of experiments.

In the Greek environment, males were considered to have much stronger self-efficacy for developing gender attitudes than females, which is the exact reverse of what happened in the Spanish group. These two arguments' explanations require further investigation (Miralles-Cardona, 2022). It was discovered that there are no appreciable gender differences in the attitudes of pre-service science teachers regarding sustainable environmental education. However, it was shown that the mean attitude measurement of female students was greater than that of male students (Keles, 2017). Overall, the study demonstrates that gender is a complicated and multifaceted element that has various effects on pre-service science instructors' views regarding experiments (Miralles-Cardona, 2022). Therefore, while examining pre-service science teachers' views about experiments, it is crucial to see gender as a variable rather than a constant.

c) Age

Age is another personal characteristic that influences pre-service science teachers' attitudes toward experiments. According to past research, older pre-service science teachers had more unfavorable opinions regarding experiments than younger pre-service

science teachers. Because younger generations are more technologically advanced than older ones, this is the case. “Because they are intelligent and laser-focused, today's youth will have an easier time understanding experiments. It was shown that pre-service male teachers who were older faced more stress. The association between age and stress was not seen among female pre-service teachers. Male pre-service teachers over the age of 50 reported much greater levels of stress than those under that age. In contrast, there is no connection between the age of female pre-service teachers and any significance” (Geng., et al, 2022, p. 8).

Because young people employ technology, virtual tests can favor younger generations more than older ones. “The importance of the stress levels of male and female pre-service teachers was assessed using a t-test. The amount of stress among males and girls across age groups was examined using a one-way ANOVA. The Chi-square test was used to examine the characteristics and hours spent on the tasks by male and female pre-service teachers” (Geng., et al, 2022, p. 5). The old group will always be behind. Due to their earlier experiences with laboratory experiments throughout their own school years, the older group will find it difficult to conduct experiments. This data demonstrates that pre-service science teachers’ opinions regarding experiments are influenced by age, a complicated and multifaceted issue, in a variety of ways. Therefore, when studying pre-service science, it's crucial to see age as a variable rather than a constant. Therefore, it is important to consider age as a variable rather than a constant in studying pre-service science teachers' attitudes toward experiments.

d) Prior experience

Pre-service science teachers who conducted experiments at the secondary level had greater confidence than those who did not. Some secondary schools do not have laboratories; thus, students from those backgrounds won't be interested in doing research at the university level. Some of them even avoid touching equipment out of fear. The attitudes of pre-service teachers regarding laboratory experiments may be impacted by this sort of circumstance. “Majority of pre-service teachers stated that it was the first time they were introduced to the technology of the Web. The advancements in technology's use in education and in technology itself inspired pre-service teachers to create more

engaging lesson plans and developed a greater interest in Web 2.0 technologies” (Gursoy, 2019). The change of curriculum may also be the reason behind this factor. In the past, there was no experiment content. But today, learners are doing experiments from the primary level. This evidence shows that prior experiences are important factors that shape pre-service science teachers' attitudes toward experiments. Therefore, it is important to provide pre-service science teachers with positive and meaningful experiences with experiments in their teacher education program.

e) Academic background

Academic background is another personal characteristic that influences pre-service science teachers' attitudes toward experiments. When a student gets low-grade marks, they may feel disadvantaged in their area of study. Higher marks can increase student interest in science experiments. The more learners face challenges in the laboratory room, the more their interest is decreasing. It was discovered that the attitude score of pre-service teachers increases with increasing grade level. Students' mean attitude scores varied significantly across grade levels; it was discovered (Keles, 2017). The grade level can increase the experiment confidence and conceptual understanding of future science teachers. These students will become more engaged, motivated, and curious about experiments and how to perform them. They will always be interested in learning new things and understand the value of doing experiments in the lab.

According to some studies, pre-service science teachers with more science courses or higher grades tend to have more positive attitudes toward experiments than those with fewer science courses or lower grades. In light of the study it might be recommended that more research be done in an effort to determine the attitudes of pre-service teachers from other disciplines and to examine various elements influencing attitudes (Keles, 2017, P. 178). As a result, academic background has a significant impact on how pre-service science teachers see experiments. However, academic background is a dynamic and linked element that interacts with other factors like personal traits, environmental circumstances, or experiment kinds rather than being fixed.

f) Beliefs

Beliefs are another personal characteristic that influences pre-service science teachers' attitudes toward experiments. Improving students' perceptions of the nature of experimental physics may require them to engage in real practices (Wilcox, 2016). Laboratory experiments are valued more highly by pre-service science teachers who regard science to be simple than by those who think it might be difficult. Pre-service science teachers' beliefs about the nature of science and the role of experiments in science affect their attitudes toward experiments. These studies suggest that pre-service science teachers who have more constructivist beliefs about science and experiments tend to have more positive attitudes toward experiments than those who have more traditional beliefs about science and experiments. It shows that beliefs are important factors that shape pre-service science teachers' attitudes toward experiments. Therefore, it is important to help pre-service science teachers develop more constructivist beliefs about science and experiments in their teacher education program.

g) Expectation and emotional attitude towards experiments.

Expectations are another personal characteristic that influences pre-service science teachers' attitudes toward experiments. Pre-service science teachers' expectations about the outcomes and benefits of doing experiments affect their attitudes toward experiments. Pre-service science teachers may get disappointed and lose interest in the subject of science if they expect to perform well in science experiments. Pre-service science teachers who have more positive expectations about conducting experiments have a tendency to see experiments positively than those who have less positive expectations. When doing these experiments, students' confidence is influenced by their expectations for the laboratory's physics investigations (Wilcox, 2016). Expectations have a significant role in determining how pre-service science teachers feel about experiments. Therefore, it's important to encourage pre-service science teachers to have a positive attitude about doing experiments as part of their teacher training.

Teachers' attitudes towards experiments are influenced by their emotions, particularly those related to enjoyment, curiosity, and satisfaction. Positive emotions, such as enjoyment, curiosity, and satisfaction, are more likely to shape pre-service science teachers' attitudes toward experiments. Conversely, negative emotions, such as anxiety,

frustration, and boredom, can delay their passion for experiments. Therefore, it is crucial to create a supportive environment for pre-service science teachers to engage in experiments in their teacher education program.

3.9. Various contextual factors influence attitudes towards experiments

Pre-service science teachers' attitudes toward experiments are influenced by various contextual factors, including curriculum, instruction, assessment, resources, culture, peers, mentors, and role models.

a) Curriculum

The teacher's curriculum, which outlines goals, objectives, and standards, can significantly impact their attitudes toward experiments, shaping their future classrooms. It provides opportunities, expectations, and guidance for conducting experiments in their teacher education program. They must learn how to perform laboratory experiments so that they may utilize their newfound knowledge with students in the future. While the experimental group was taught the subject matter using POE(Predict, Observe, Explain) worksheets, the control group was instructed using conventional teaching techniques employing the material from the fourth-grade scientific curriculum (Arslan, 2020). The ability to perform experiments in their future classrooms will make it the best opportunity of a lifetime for pre-service science teachers. The present teachers will be well-trained, which will also help the government and save money, compared to the former teachers who struggled to perform experiments with their learners.

According to Artun (2020), it is obvious that teacher preparation is just as important for science curriculum as learner preparation. Instructors play an important role in assisting pre-service science teachers in achieving the curriculum's goals (Artun, 2020). Curriculum can influence pre-service science teachers' attitudes toward experiments by providing them with guidance for doing laboratory experiments. Docherty-Skippen (2020) believes that pre-service elementary teacher science and technology curricula should have a solid pedagogical base focused on the design and delivery of hands-on experimentation that improves science and technology literacy.

b) Instruction and assessment

The instruction is the method or approach that is used to deliver the curriculum and facilitate the teaching and learning of science. The instruction can influence pre-service science teachers' attitudes towards experiments by exposing them to different types and levels of experiments in their teacher education program and their future classrooms. The real laboratory uses manuals or handouts to instruct on how you should conduct the experiments. Laboratory manuals are used to enhance the enjoyment and satisfaction of pre-service science teachers when doing experiments. "(Virtual Reality) VR in scientific education study, the viability of this technology in science laboratory instruction will be recognized more. In comparison to traditional methods of instruction, the researchers discovered that computer-assisted science instruction was better for students' learning of SPS(Science Process Skill)" (Artun, 2020).

The assessment is the process or tool that is used to measure and evaluate the teaching and learning outcomes of science. The assessment can influence pre-service science teachers' attitudes towards experiments by providing them with feedback, recognition, and motivation for doing experiments in their teacher education program and in their future classrooms. Despite the fact that lab reports and written assignments may be the ones that best reflect how science is actually communicated, it is challenging to use them as an assessment of a research's effectiveness because of the subjective nature of the procedure for assessment and the range of different students across studies (Brinson, 2015, p. 221). A teacher's self-efficacy and appreciation for experiments can be enhanced through formative or authentic tasks, enhancing their understanding of the relevance and importance of experiments in science learning and teaching. Achievements in virtual, remote, and hands-on laboratories differ in every aspect of the learning result (Hernández-de-Menéndez, 2019).

However, as results and assessment methods differed, the KIPPAS framework was created as a guide for assessing and comparing plans for different types of laboratories(Hernández-de-Menéndez, 2019). According to Gericke (2023), teachers face a major challenge in assessing laboratory work, which has been identified as a major challenge over the past two decades. Traditional methods of assessment are insufficient,

and further research is needed to explore alternative assessment practices besides traditional lab reports.

c) Resources



The resources are the materials or equipment that are available and accessible for doing experiments in science. The resources can influence pre-service science teachers' attitudes toward experiments by affecting the feasibility, quality, and diversity of doing experiments in their teacher education program and in their future classrooms. Hamed (2020), indicate that the model to be implemented will combine a virtual lab in the form of interactive simulations and online films with a real practical lab utilizing a blended learning method, in opposition to previous models that completely replace virtual experiments for real laboratory work. For example, resources that are adequate, reliable, and varied can enhance pre-service science teachers' confidence, enjoyment, and curiosity in doing experiments, as well as their understanding of scientific concepts and processes.

Hernández-de-Menéndez., (2019) suggests that organizations invest resources in various laboratory types to enhance students' technical skills and enhance their knowledge acquisition. According to Hernández-de-Menéndez, (2019), virtual labs enable students to learn system mechanics, analyze parameter variations, and understand problems. They also facilitate the sharing of skills and resources, enhancing the educational experience by providing a more interactive and engaging learning environment (Hernández-de-Menéndez, 2019). Virtual experiments are advantageous as they don't need a lot of resources. The only resources required are a smartphone or laptop that is connected to the internet. On the other side, according to Simanjuntak (2023), virtual experiments have limitations such as insufficient resources and limited internet access for students without cell phones. Resources can affect pre-service science teachers' attitudes about experiments, as the quality of experiments depends on resource availability.

d) Culture

Culture plays a crucial role in shaping the teaching and learning of science, particularly in the context of experiments. It influences pre-service science teachers' attitudes towards

experiments, influencing their perception and interpretation of them. Science, technology, engineering, and mathematics have a strong culture in terms of ideas, norms, attitudes, and values, which conflict with women's feelings of belonging and interest (Buenestado-Fernández, 2023). A culture that supports inquiry-based learning and scientific literacy can foster interest, value, and confidence in experiments, while a culture that emphasizes rote learning and standardized testing can hinder these teachers' understanding of the nature and role of experiments in science. "I would prefer to use hands-on lab approach since student should be familiar with the settings of laboratory and how to perform experiments" (Kapici & Akcay, 2018, p. 46). Pre-service attitudes regarding experiments might be influenced by the culture and language utilized when conducting experiments.

- e) Peers, Mentors, and Role models can influence pre-service science teachers' attitudes toward experiments.



Teachers play a crucial role in shaping the attitudes of pre-service science teachers toward experiments. Students become inactive and bored, according to Simanjuntak (2023), when they have not interacted directly with their teachers and peers for a long time. They are influenced by their peers, who share similar learning experiences and can provide social support, feedback, and collaboration. Real laboratory activities are the finest since they allow students to interact with one another. This might be helpful since it allows pre-service science teachers to exchange their knowledge and hands-on experiences with each other. Atta (2023), believed in peer learning, in which students learn by interacting with peers and more experienced adults and interacting with teachers (Zhu, 2023). The instructor encouraged the pre-service teachers to communicate and share their knowledge of the subject with their peers in the groups during the POE activities (Mutlu, 2016). Peer teaching gives students the opportunity to learn something new while also being a resource for others (Sopandi, 2022). Positive peer attitudes can enhance the enjoyment, curiosity, and satisfaction of pre-service science teachers in experiments, while negative peer attitudes can reduce these qualities.

Mentors, experienced or expert teachers, guide and support pre-service science teachers in their professional development. They can provide modeling, coaching, and scaffolding for experiments in their teacher education program and future classrooms. Pre-service teachers are experiencing significant stress resulting from a lack of experience and tension from mentors and university lecturers during their teaching practicum (Geng., et al, 2022). Students who get poor mentoring may lose interest in science. Mentors are available to help students succeed in their classes. When doing experiments, you will encounter demonstrators who will assist you. Positive mentors can enhance self-efficacy and outcome expectancy in experiments, while negative mentors can reduce these.

Role models, influential or inspirational individuals who demonstrate desirable behaviors or achievements related to science or experiments, can also influence pre-service science teachers' attitudes toward experiments. Parents who work in STEM fields act as role models for their boys and inspire their daughters to pursue careers in similar fields (Buenestado-Fernández, 2023). Because there are not enough women in science, girls, and adolescents are less likely to pursue a scientific profession because they do not see themselves represented (Buenestado-Fernández, 2023). When pre-service science instructors do not receive inspiration from senior scientists, their level of interest in science decreases. The more they witness people succeeding in the field of science, the more interested they get in both science and laboratory experiments. Positive role models can enhance pre-service science teachers' interest and value in experiments, as well as their career interest in science. Conversely, negative role models can reduce these teachers' interests and value in experiments and their career interest in science.

3.10. The Role of Experiments in Science Education and Pre-service Teachers Attitudes

Science education is an important component of a well-rounded education because it provides students with the information and skills they need to comprehend and engage in the world of science and technology. According to Kazempour and Sadler (2015, p.250), science concepts need to be “taught” or “shown” to students, and science experiments are meant to confirm teacher instructions and textbook explanations and to make science learning fun. Experiments have become a powerful tool for improving the effectiveness of science education, as they engage students in hands-on, interactive

experiences that promote critical thinking, problem-solving, and a deeper understanding of scientific concepts (Kazempour & Sadler, 2015, p.250). Pre-service teachers, who are currently training to become educators, play a significant role in shaping the future of science education (Gracia et al, 2019). Their attitudes and beliefs about teaching methodologies, including experiments, are central to the transformation of science education (Fan et al, 2013). Understanding the transformative impact of experiments on pre-service science teachers is vital to improving science education at all levels.

Pre-service teachers' attitudes regarding the use of experiments can also have an impact on their teaching approaches. Those who regard experiments as important tools are more likely to employ them successfully, hence improving the quality of scientific education provided to their learners (Tomas et al, 2017). Those with negative views, on the other hand, may neglect tests, missing out on the benefits they provide. According to Kula (2022), examining these attitudes helps to the larger discussion of scientific education by underlining the necessity of encouraging creativity, discovery, and experiential learning in the science classroom. "Experiments offer a bridge between theoretical scientific principles and practical applications, making learning science a dynamic and engaging experience. Understanding how pre-service teachers view and utilize experiments is crucial for optimizing their effectiveness in science instruction. Factors such as personal experiences, teacher education programs, resource availability, and support from mentors and institutions can influence pre-service teachers' attitudes towards experiments" (Ajayi, 2019, p. 1).

3.11. Challenges and Impact of Experiments on Pre-Service Teachers Teaching Practice

Challenges faced by pre-service teachers when integrating experiments into their teaching practices include lack of resources, time constraints, and classroom management issues. Recognizing these obstacles provides an opportunity to develop solutions and support systems that empower pre-service teachers to effectively use experiments in their classrooms. Experiencing experiments during teacher training can influence the attitudes of pre-service science teachers in various ways, such as sensitive confidence in their subject matter knowledge and increased excitement for teaching. These changes can have a great impact on the effectiveness of their future classrooms.

Laboratory activities provide students with cognitive, emotional, and psychomotor abilities such as planning experiments and comprehending how theories develop from experiments (Harman, 2016). Experiments can also shape pre-service teachers' perspectives on teaching methods, the value of hands-on learning, and the importance of fostering scientific curiosity among their learners.

Lee et al. (2018) found that physics students who participated in practical work outperformed those taught using the traditional teaching style. If a practical assignment is effectively prepared and expertly presented by the teacher, it may have an impact on students' learning process. Gericke et al. (2023) stated that the most relevant idea for collecting the recognized phenomena of interest in this investigation is laboratory work. According to Agustian and Seery (2017), laboratory instruction became a separate and independent component of education, with the emphasis aimed to teach students about how to "do science" (p. 518). So, the key objective of laboratory instruction is to immerse students in the scientific method by offering them opportunities to actively engage with materials and apparatus while they are performing experiments.

3.12. Exploring Pre-Service Teachers' Attitudes Towards Laboratory Experiments in Science Education: Implications for Teaching and Learning

There is a long-running discussion about the role of laboratory work in science education that stretches back decades and demonstrates the belief and interest of teachers and researchers all around the world in the usefulness of laboratory work for understanding science (Harman et al, 2016). According to Frod (2013), learning by doing is more effective than learning by listening or reading, and when students learn by doing (using information to solve a problem), they are more likely to remember what they have learned, as well as process the information they are receiving and reflect on how they learned. Laboratories are one of the most common locations for conducting experiments. According to Harman et al (2016) p12, the statement "I heard, but I forgot." I noticed and remembered. The words "I did, and I understood" emphasize the importance of laboratories in science education. From this point of view, a laboratory is an atmosphere in which students learn through hands-on activities, living, and receiving first-hand tangible experiences (Harman et al. 2016).

Science teachers' attitudes towards experiments are of academic interest and practical implications. "Understanding these attitudes can help modify curricula and provide necessary skills for successful teaching. Investigating difficulties and barriers in integrating experiments into curricula can help future educators prepare for the complex process. A positive attitude can inspire curiosity, critical thinking, and passion for science among the next generation" (Blatti *et al.*, 2018, p.2857). This study aims to explore, understand, and shed light on pre-service teachers' attitudes towards experiments in teaching and learning science, contributing to the ongoing dialogue on enhancing the effectiveness of science education and inspiring future generations to become scientifically literate, curious, and engaged citizens.



3.13. Different Types of Experiments Affect Pre-Service Science Teachers' Attitudes Toward Experiments

According to Claesson (2023), educational labs are classified into three types:

- A school laboratory with equipment for performing hands-on laboratory work.
- Remote laboratory, which is frequently located somewhere and has genuine equipment that the student controls remotely using a computer.
- Simulated laboratory, a computer simulation of laboratory operations.

a) Hands-on experiments

According to Brinson (2015.), "hands-on laboratories involve a physically real investigative approach. Hands-on activities are experiments in which students handle materials and equipment while gathering data". To learn experimental techniques and absorb science material, students must practice practical and motor skills, as well as gain hands-on experience with physical equipment (Akçayır, 2016). Research from the past indicates that hands-on experiences in the science laboratory are essential to the study

of science. Up until recently, the only experiences from which these conclusions could be formed were real, hands-on laboratory experiments. The techniques and processes of what has traditionally been known as "hands-on" laboratories have all been challenged and transformed by computer-based and virtual simulations. Regarding their reliability as standalone replacements for hands-on laboratories, all of these lab teaching styles have been considered from various yet well-developed perspectives (Brinson, 2015, p. 219).

Hands-on activities are a powerful tool in science education, allowing students to engage in active inquiry and problem-solving. These activities help students connect abstract ideas to tangible facts and apply scientific principles to real-world problems. They also boost students' interest in science, pique their curiosity, and increase motivation. By allowing students to choose their own themes, approaches, and objectives, hands-on activities strengthen their intrinsic drive for science and self-determination. Furthermore, hands-on activities boost students' self-efficacy and confidence in science through feedback, praise, and recognition. "Some researchers suggest that traditional (hands-on) laboratories provide for more information, such as many more signals when working with real apparatus. Regarding the effect that these advances in technology could have on students' laboratory learning, no conclusion has, however, been reached" (Brinson, 2015, p. 220).

Hands-on activities are a powerful tool in science education, enhancing students' understanding of scientific concepts and processes. These hands-on activities foster cognitive development and scientific literacy by providing students with meaningful learning experiences. They also stimulate students' interest and curiosity for science by allowing them to explore, discover, and create. Because of the lack of laboratory facilities, Duban (2019) claimed that only a few learners were able to engage in hands-on activities. Pre-service science teachers who participate in hands-on activities show higher levels of motivation for science. "Hands-on and mind-on activities are helpful in developing students' understanding of the methods that are used to obtain this type of knowledge" (Claesson, 2023).

Hands-on activities can also boost students' confidence and self-efficacy in science by providing feedback, recognition, and support. Students who participate in hands-on

activities show higher levels of confidence in science. They empower students to take ownership and responsibility for their learning, overcoming challenges and difficulties. “The study indicates that while there is a general trend to increase hands-on laboratory experiences for undergraduate engineering students, the quality of these experiences should be given greater attention. Laboratory experiences are essential in engineering education for acquiring hands-on skills and bridging the gap between theory and practice” (Cullin, 2017).

In the current study, some of the class teachers had laboratory lessons during their undergraduate education, others obtained in-service training after starting employment, and some were educated as scientific teachers in various fields (Duban, 2019). The South African Institute of Physics (SAIP)-Vhembe Maths, Science, and Technology teacher training program aims to address the challenges faced by pre-service science teachers at the University of Venda. By providing comprehensive training, the program aims to improve the academic performance of scientific students. Pre-service teachers who are not trained in experiments will assist learners by conducting experiments at their individual schools. The SAIP, in collaboration with the Vuwani Science Center, offers a three-day training program focusing on theory and practicals. This approach saves time and money for schools in the Vhembe district, as they can choose days for learners to perform experiments independently. This study aims to save money and time by ensuring that pre-service teachers receive comprehensive training throughout their undergraduate studies, thereby reducing the need for qualified teachers.

In conclusion, hands-on activities are essential for students' cognitive development, scientific literacy, and affective development. However, they need to be well-designed, implemented, and integrated with other forms of instruction to achieve optimal results. Ultimately, hands-on activities should be feedback-oriented, recognition-oriented, and support-oriented to achieve optimal results. Hands-on activities can have positive or negative effects on pre-service science teachers' attitudes toward experiments, depending on how they are designed, implemented, and integrated with other types of experiments.

b) Virtual Experiments

Virtual labs are computer-based environments that simulate real laboratory settings and equipment that allow students to perform experiments online. (Virtual Reality)VR-based scientific laboratory practices and educational games increase students' brain activity, making them an effective instrument for science laboratory education, particularly in situations of poor laboratory facilities, and therefore improve the learning experience (Artun, 2020).

“The following are the primary advantages of using a virtual lab in addition to a real one.

First, the general view is that simulations and virtual laboratories promote greater levels of thinking and memory because they are learner-centered and inquiry-based.

Second, virtual laboratories are viewed as a low-cost alternative to traditional laboratory experiments. Experiments that would be too expensive (in terms of instruments or supplies), difficult, or even dangerous to conduct in the real world can be safely duplicated in the virtual environment.

Third, learners' attitudes regarding utilizing computers for learning improve. They find simulation of laboratory work to be motivating and educational” (Bortnik, 2017).

Educational objectives like design skills and conceptual understanding influence the debate over the value of different laboratory categories. Today, RLs and simulations can replace hands-on laboratories to promote understanding and learning of concepts. A set of activities, including simulations remote and hands-on experiments, was designed to engage students in the learning process. Results showed that remote laboratory VISIR is an effective tool for active learning (Claesson, 2023).

Furthermore, because most virtual chemical laboratories are designed for secondary schools, their application in teaching and learning chemistry, particularly analytical chemistry, falls short of university requirements. There are a limited number of virtual laboratories that can be utilized for university courses. When studying about the actual world, students might benefit from virtual laboratories. There is evidence that only a well-balanced mix of real and virtual laboratories can improve science learning and foster scientific activities. Combining virtual and real laboratories has advantages in terms of

meeting learning objectives. However, several research studies demonstrate no difference in increased academic achievement between actual and virtual experiments.

3.14. Pre-Service Teachers Views About Distance Learning Virtual Laboratories

Teachers have used traditional teaching and have not explored any other forms since traditional life was introduced into the school system. This type of teaching cannot be done remotely. It constantly asks teachers and students to meet and teach face-to-face. Kizilay., et al, 2022, p. investigated the views of pre-service science teachers on simulated laboratory within distance education. They found that most pre-service teachers understand virtual laboratories as digital platforms. The approach was used in order to determine the point of view of pre-service teachers. The research sample size was 82 second-year pre-service teachers, 46 females and 36 males. The virtual laboratory experiment was carried out by pre-service teachers from a distance. The findings were compiled and presented in three formats.

“Pre-service teachers came up with different definitions of what a virtual laboratory is. Even though some of the pre-service teachers did not fully explain what a virtual laboratory is, some didn’t even answer at all. This shows that some pre-service teachers are not aware of the definition, and they don’t even know what a virtual laboratory is. There is a huge gap in the study since some pre-service teachers can’t define virtual laboratories. Pre-service teachers define a virtual laboratory as an online laboratory simulation” (KIZILAY, 2022, p.191). In this case, some pre-service teachers emphasize that virtual laboratories must be done in virtual environments, while others state that it can be done everywhere every time. On the other hand, Ben Ouahi (2022), indicate that “most teacher respondents believe that the use of interactive simulation can play a role in improving the quality of teaching and learning because its use in the classroom can help students understand changing events, learn concepts more easily without getting bored and improve their understanding of the experimental process”.



3.15. Advantages and Disadvantages of Real and Simulation Experiments

a) Advantages of simulation

Simulation can provide a safe and controlled environment for pre-service science teachers to practice what they've been taught. Benefits of doing simulation experiments are that, pre-service science teachers will have time to explore scientific phenomena without causing any harm or damage to themselves, others or the real world. Cayvaz (2020) found that middle school students' success in the subject of work and energy was much higher when simulation-based training was used. Simulation can foster engagement and motivation among students by making science learning more interactive and fun. Simulation can also appeal to different learning styles and preferences of students. It can also enhance the development and assessment of various cognitive and affective outcomes such as science process skills, critical thinking, problem-solving, creativity, communication, attitude, and interest. "The availability of materials is boundless, and their quality is consistently high. They are readily accessible, which helps to save valuable time for both teachers and students during the experiment setup" (Leung, 2021, p. 63). You can carry out tests wherever you wish. This sort of experiment is extremely beneficial to the department since it saves both time and money.

Simulation experiments offer numerous advantages for pre-service science teachers, providing a safe and controlled environment to explore scientific phenomena without harming themselves or others. Studies have shown that simulation-based training leads to higher success rates among middle school students, fostering engagement and motivation among students. Simulation can also appeal to different learning styles and preferences, enhancing cognitive and effective outcomes such as critical thinking, problem-solving, creativity, communication, attitude, and interest (Huang et al., 2022). However, simulation experiments can be costly and time-consuming to design, develop, internet, and maintain, requiring advanced technology equipment, software, and expertise that may not be readily available and affordable for many pre-service science teachers. Hernández-de-Menéndez (2019) suggests that students may display a lack of seriousness, accountability, and carefulness in some areas due to negative commitment.

Pre-service teachers will develop psychomotor, cognitive, and emotional abilities. Those abilities will come in handy when they become certified teachers. Experiments taught to

pre-service science teachers will assist schools once they begin working. They will be able to perform experiments for their learners online. Schools without built laboratories will benefit the most. These kinds of schools are suffering, resulting in poor science results. Virtual laboratories save time and money (Leung, 2021), and can accommodate more pre-service teachers in one time (KIZILAY, 2022).

b) Disadvantages of simulation

Simulation can be costly and time-consuming to design, develop, internet and maintain. It requires advanced technology equipment, software and expertise that may not be readily available and affordable for many pre-service science teachers. According to Leung (2021), the fast findings provide instructors more time to provide helpful feedback to students. They therefore assist students in connecting observations to concepts (content knowledge) more effectively. Simulation might also introduce errors in the data collection and analysis methods. “Students may display a lack of seriousness, accountability, and carefulness in some areas due to negative commitment. Even with high-performance simulators, data from simulated laboratories is not accurate” (Hernández-de-Menéndez, 2019, p. 954).

A disadvantage of simulation experiments is their close relationship to theory learning, as they do not involve practical or physical action. When pre-service teachers can see and touch materials, they learn better. However, simulation experiments may not provide more permanent learning because they do not turn into action, as there will be little interaction between the lecturer and the pre-service teachers, which may result in a lack of psychomotor skills. Simulation experiments offer numerous benefits for pre-service science teachers, but they also have drawbacks. They can be costly and time-consuming to design, develop, and maintain, and may introduce errors in data collection and analysis methods. “The impacts of simulations in education have been actively investigated and assessed; it is important to understand why teachers use these learning strategies in their classrooms and how they are used during teaching” (Price et al., 2018).

The disadvantage of simulation experiments is that they are closely related to theory learning. No practical or physical action will be taken. When pre-service teachers can see

and touch materials, they learn better. Simulation is more like traditional education in that the lecture is delivered, and students listen to what is stated. Students may be ineffective in this sort of experiment since they will be listening and watching but not touching. When pre-service teachers do experiments face to face, they can learn more effectively. There will be little interaction between the lecturer and the pre-service teachers, which may result in a lack of psychomotor skills. "Pre-service teachers stated that virtual(simulation) experiments provide less permanent learning because they did not turn into action" (KIZILAY, 2022, p. 123).

c) Advantages of real(hands-on)

Real experiments can provide a high level of ecological validity, meaning that the results can be more applicable and generalizable to real-world contexts and situations. Real experiments can capture the complexity and dynamics of the natural environment and the interactions among various factors that may affect the attitudes of pre-service science teachers towards experiments. According to Hernández-de-Menéndez (2019), real data is generated in physical laboratories, where by simulated laboratory may not always provide correct results, despite their technological developments (p. 954). Real experiments can allow for the exploration of new and unexpected phenomena, meaning that the researchers can discover new insights and relationships that may not be evident or possible in laboratory or simulated settings. Real experiments can also test the robustness and reliability of the existing theories and models in different conditions and scenarios.

"Real laboratories provide student with a hands-on experience that improves their understanding towards the use of experiments. students draw conclusions based on their observation, since those experiments involves direct interaction with materials and instruments. These experiments create a context for the theoretical concepts taught in class, reinforcing students' knowledge" (Brinson, 2015, p. 219). "Genuine experiments spark curiosity and foster the spirit of scientific inquiry, enabling students to ask questions, formulate hypotheses, and explore answers through direct observation and experimentation. They often promote collaboration and teamwork, making what students learn more relevant and applicable" (Kirmizigul et al., 2021).

d) Disadvantages of real experiments

Real experiments can have a low level of internal validity, meaning that the results can be less accurate and reliable due to the lack of control over the extraneous variables that may confound the effects of the independent variable on the dependent variable. Real experiments can also introduce ethical and practical issues, such as informed consent, random assignment, or data collection and analysis. “Using real equipment incorrectly might result in dangerous situations” (Hernández-de-Menéndez, 2019, p. 954). Real experiments can be difficult to replicate and verify, meaning that the results can be less consistent and credible due to the variability and unpredictability of the natural environment and human behavior. Real experiments can also pose challenges for the interpretation and explanation of the results, as there may be multiple causes and effects involved. Open investigations take a very long time to reach an acceptable conclusion, claims (Leung, 2021).

“Conducting real experiments may also raise safety concerns due to handling potentially hazardous materials or equipment. Safety protocols, supervision, and adherence to safety guidelines are essential for ensuring student safety. Some experiments may be impractical due to geographical, environmental, or budgetary constraints, and some experiments may yield inconsistent results due to variations in experimental conditions or human error. Replicability is a fundamental aspect of the scientific method, and real laboratory experiments may require teachers to possess specific expertise in experimental techniques and safety protocols” (Kirmizigul et al, 2021, p.193).

4. CONCLUSION

I will be investigating the effects of experiments on the attitudes of pre-service science instructors toward science. My research question was, "How do experiments affect the attitudes of pre-service science teachers toward science?". Experiments are effective learning tools that can improve the attitudes of pre-service science teachers toward science; different types of experiments have different effects on pre-service science teachers' attitudes toward science; and personal and contextual factors influence pre-service science teachers' attitudes toward experiments.

Some studies have used a small sample size or a non-random sampling method, which may limit the generalizability and validity of the findings. Zhu (2023) involved only 25 pre-service science teachers from one teacher education program in China. The study by Harman (2016) used a convenience sampling method to select 63 pre-service science teachers from one university in Turkey.

Most of the studies have used a single or limited measure of pre-service science teachers' attitudes, while others focused only on simulation-assisted laboratory applications. The study by Aslan (2017), used only one scale to measure pre-service science teachers' attitudes toward science experiments. Some studies have focused on a specific or narrow aspect of laboratory experiments, which may not reflect the diversity and richness of the laboratory experiences.

Some studies have lacked a theoretical framework or a clear rationale for the design and implementation of the laboratory experiments, which may affect the quality of the research. Harman (2016) did not specify any theoretical framework or model to guide their laboratory course, while others did not explain why they chose simulations as their laboratory method.

However, there are flaws and gaps in this literature review, such as being overly uniform and not addressing some specific elements or dimensions of pre-service science teachers' aspects regarding experiments.

CHAPTER 3: RESEARCH METHODOLOGY

1. INTRODUCTION

This chapter summarises the research methodology used in the study to investigate pre-service teachers' attitudes toward experiments in science education. It interprets the demographics, sampling strategies, data collection methods, data analysis processes, and research methodology used in this investigation. The technique successfully answers the research questions while ensuring the validity and reliability of the results.

The study uses a quantitative research methodology, which makes it possible to gather numerical data for statistical analysis. To collect structured responses from pre-service instructors on their preferences for actual vis-a-vis virtual trials, a survey study methodology was selected. With a sample size of 82 participants chosen by stratified random selection to ensure representation across gender and other demographic data, the target group is undergraduate pre-service science teachers. Google Forms and WhatsApp were used to distribute structured questionnaires for data collection, guaranteeing accessibility and effective response gathering. Likert-scale items measuring attitudes toward experiments were included in the questionnaire along with background and demographic data.

The use of experiments on the attitudes of pre-service science teachers were examined in this study. The purpose of this study was to investigate pre-service attitudes concerning laboratory experiments. Both real and simulation studies were prioritized. The key issue is that not performing experiments on pre-service science teachers has an impact on them in the future. They will be afraid of the laboratory and will be unable to conduct experiments for their learners. Qualified teachers who are currently in the classroom lack knowledge in conducting experiments, resulting in learners performing badly in their scientific subjects. Pre-service science teachers who participate in laboratory experiments as part of their training have more positive attitudes regarding the teaching of science than those who do not. Aside from that, this study measures pre-service teachers' attitudes and behaviour in two types of experiments (real and simulation). The main objective of this study was to investigate the impact of laboratory experiments on pre-service science teachers' attitudes toward experiments, as well as to compare the

effects of different types of laboratory experiments, such as real or simulation, on pre-service science teachers' attitudes toward experiments. The researcher's assumption is that laboratory experiments have a positive effect on pre-service science teachers' attitudes, and there is no direct connection between virtual and real experiments.

IBM-SPSS version 28 was used for data analysis, and both descriptive and inferential statistical tests were performed. Non-parametric methods including the Mann-Whitney U Test, Chi-Square Test, and Wilcoxon Signed Ranks Test were used in the study to compare attitudes and find meaningful differences across groups. To identify the proper statistical techniques, Levene's examine, Brown-Forsythe Test, and Fligner-Killeen Test were used to examine measures of normality and homogeneity of variances. The next parts explore the research design, sample processes, data collection methods, and analytical techniques employed in the study. This chapter offers a thorough description of each methodological step, guaranteeing transparency and reproducibility in the research process.

2. RESEARCH PARADIGM

A research paradigm is the logical basis around which a study is formed. It provides a set of beliefs and understanding upon which the research project's ideas and methods are based. Paradigms are broad perspectives or ideas (Perera, 2018). Perera (2018, p. 17) defines research paradigms as "a set of common beliefs and agreements shared by scientists on how problems can be understood and addressed." Research paradigms are also meant for scientists to reply to three fundamental concerns, ontology, epistemology, and methodology (Perera, 2018). Research paradigms are classified as positivism, interpretivism, post-positivism, critical theory (ideology), constructivism, and/or pragmatism. As stated by Selvan (2017), positivists believe that reality is a single solid space that can be reached using different types of methods. Experiments, for example, only provide objective answers that are not open to alternative interpretations. In keeping with this, positivists believe that reality is provided objectively and can be measured using

attributes that are independent of the researcher's equipment. It is assumed that knowledge is objective and quantitative.

The study is grounded in the positivist research paradigm, which emphasises objectivity, quantification, and statistical analysis (Reference). The positivist paradigm aligns with the study's quantitative approach, enabling the researcher to measure pre-service teachers' attitudes toward experiments systematically and empirically (References). Positivism assumes that reality is objective and measurable, which supports the use of structured questionnaires to collect data. This paradigm facilitates hypothesis testing through statistical methods, ensuring that the research findings are valid, reliable, and generalisable to a larger population of pre-service science teachers (references).

By adopting a positivist paradigm, this study focuses on identifying patterns, relationships, and trends in attitudes towards real versus simulated experiments in science education. The use of non-parametric statistical tests further strengthens the reliability of the findings by accommodating data that do not necessarily conform to normal distribution assumptions. In summary, the positivist paradigm provides a structured and objective framework for this study, ensuring that the research findings contribute to an evidence-based understanding of pre-service teachers' perspectives on science experiments.

3. RESEARCH APPROACH

The study employs a quantitative research approach, which focuses on the collection and analysis of numerical data to identify patterns, relationships, and trends. This approach is suitable for measuring attitudes, perceptions, and experiences of pre-service teachers toward experiments in science education.

The quantitative approach allows for the application of statistical techniques, ensuring objectivity and precision in data interpretation. By using structured questionnaires with closed-ended questions, the study ensures consistency in responses, making it possible to compare findings across different demographic groups such as gender.



Furthermore, this approach enables the researcher to test hypotheses, such as whether gender significantly influences pre-service teachers' attitudes toward experiments. The use of descriptive and inferential statistical methods enhances the ability to generalise findings to a broader population of pre-service science teachers.

In summary, the quantitative research approach is appropriate for this study because it provides measurable and reliable data that can be analysed systematically, ensuring valid conclusions about the attitudes of pre-service teachers toward experiments in science education.

4. METHODOLOGICAL DESIGN

A research methodology is systematic and purposeful, planned to yield data on a particular research problem (McMillan & Schumacher, 2010). A research methodology is a means to describe how a researcher plans to conduct their investigation. It's a methodical, logical approach to solving a research challenge. According to Creswell (2016), research design is a pattern that the researcher follows when collecting, evaluating, and interpreting data. This type of quantitative design was used for collecting and analysing data to answer research questions and hypotheses, by allowing systematic collection of numeric data to measure attitudes and analyse relationships among variables. A quantitative research technique can give useful insights into the effects of laboratory activities on the attitudes of pre-service science teachers by collecting and analysing numerical data (Refs). "Generalisability is a common concern in quantitative research." A well-designed quantitative study's findings may be extended to a larger population of pre-service science teachers, yielding insights that may extend beyond the specific group being examined" (Williams, 2007, p. 69). "Quantitative researchers are looking for explanations and predictions that will lead to other people and places. The goal is to establish or validate relationships and develop generalizations that add to the theory" (Leedy and Ormrod, 2001, p. 102).

This study investigates the use of laboratory experiments on pre-service science teachers' attitudes, focusing on both virtual and simulation experiments. The key issue is

that not conducting experiments on pre-service teachers can negatively impact their future performance, as they may be afraid of the laboratory and unable to conduct experiments for their learners (Refs). Pre-service science teachers who participate in laboratory experiments as part of their training have more positive attitudes towards the teaching of science. Quantitative research methods, such as Leedy and Ormrod's approach, are systematic procedures for collecting and analysing numerical data to answer research questions or test hypotheses. This research technique can provide useful insights into the effects of laboratory activities on the attitudes of pre-service science teachers by collecting and analysing numerical data. Quantitative research provides for the collection of objectives, numerical data, which in this situation is critical since it allows for standardised measurements that are less affected by bias or discrimination. "Quantitative research involves data collection that is typically numeric, and the researcher tends to use mathematical models as the methodology of data analysis. Additionally, the researcher uses the inquiry methods to ensure alignment with statistical data collection methodology" (Williams, 2007, p. 67).

The study employs a cross-sectional survey design, meaning that data was collected at a single point in time. This design is beneficial for assessing pre-service teachers' attitudes toward experiments and comparing their perspectives based on demographic factors such as gender. The methodological design of this study provides a structured framework for collecting, analysing, and interpreting data related to pre-service teachers' attitudes toward experiments in science education. The research employs a survey-based quantitative research design, ensuring systematic data collection and statistical analysis to draw meaningful conclusions. Pre-service attitudes were evaluated by means of Likert-scale survey questions, which were designed to measure pre-service teachers' attitudes towards the use of experiments. Data was analysed using IBM-SPSS at a single point in time, allowing comparison of responses across different demographic groups (gender).

5. POPULATION AND SAMPLING

A research population is also defined as a well-defined group of people who have comparable features (Refs). Differentiating evidence of the target population was required in this study to carry a basis from which sample units and sample size were taken. When doing research, it was especially difficult to get data from every person or item of the community; hence, sampling came in helpful. The intended target group were all pre-service science teachers who are currently enrolled in teacher education programs or undergoing training to become science teachers. The target population comprised undergraduate pre-service science teachers. A stratified random sampling technique was used to ensure gender representation. Conducting research with a larger population may be more resource-intensive and time-consuming, making a sample size of 82 more manageable within the constraints of the study.

A sampling method is a way in which the individuals from the subpopulation are chosen. Stratified random sampling method was used in this case (Refs). The participants were chosen using a stratified random sampling. A stratified random sample divides the population into mutually exclusive groups, such as age/gender groupings, and then draws random samples from each category. Students were sorted into groups, yet each pre-service science teacher in each group had an equal chance of getting chosen. The sample size consisted of 82 respondents (36 males and 46 females). A sample size of 82 was sufficient to capture meaningful variation and patterns within that population subset. The use of stratified random selection guaranteed that any differences between pre-service science teacher's groups were considered in this study. This provided a deeper and more accurate insights into how scientific investigations changed the attitudes of various groups of pre-service science teachers. Quantitative research allowed for the establishment of fundamental relationships. By randomly assigning pre-service teachers to experimental and control groups, the researcher had the confidence in attributing any observed changes in attitudes to the laboratory experiments.

6. RESEARCH INSTRUMENTS

A structured questionnaire was used to measure pre-service teachers' attitudes towards the use of experiments in science education. The questionnaire included the following key elements:

- Demographic information (which includes gender, age, area of specialisation and number of science courses taken)
- Independent variable ratings (which included the availability of resources at their institution, as well as their prior experience with real and simulated experiments.)
- Attitude towards science experiments (This part uses a five-point Likert scale ranging from 1=strongly disagree to 5=strongly agree, to measure the pre-service teachers' attitudes.

To test the validity of the questions I conducted a pilot test of the questionnaire with a small sample of pre-service teachers who are like the intended study population. I asked participants to complete the questionnaire and provide feedback on the clarity, relevance, and comprehensibility of the items. Pilot testing helped identify any ambiguities, confusing items, or response options that needed clarification or revision.

A questionnaire instrument's reliability is crucial for ensuring its validity and reliability. To assess the reliability of a questionnaire instrument, I used method such as internal consistency. Internal consistency reliability measures the correlation between items within the questionnaire. This type of reliability is used to measure Likert-scale questions, to assess how they link to one another. The statistical measure that I've used to assess internal consistency reliability is called Cronbach's alpha. The Cronbach's alpha coefficient was 0.878, which indicate high internal consistency. I used Cronbach's alpha to ensure that the questionnaire instrument produces consistent and reliable measurements of the constructs being assessed, enhancing the validity and trustworthiness of the study's findings.

7. DATA COLLECTION PROCEDURE

Data collection was conducted using structured questionnaires distributed digitally via Google Forms and WhatsApp, ensuring accessibility and efficient response collection. The questionnaire included Likert-scale items measuring attitudes toward experiments, as well as demographic and background information.

By comparing the two types of laboratory experiments, the researcher could quantitatively measure the change in attitudes. Pre-service science teachers administrated a questionnaire assessing and measuring their attitudes after the program, they were expected to complete the questionnaire and submit the feedback. The researcher used structured questionnaires with Likert scales to quantify attitudes, making the results more reliable and replicable. "Likert scale is a rating scale that is commonly used in quantitative research to measure the intensity or strength of respondents' attitudes" (Subedi, 2016, p. 36). Participants were asked to rate their attitudes on a scale, typically from "Strongly Disagree" to "Strongly Agree." The data collected from these scales were analysed quantitatively to understand shifts in attitude.

Firstly, the experiments were utilised to examine pre-service teachers' views after the experiment. Ohm's law and resistance is the name of the experiment that these pre-service science teachers were given. The experiment's goal was to calculate the resistance per centimetre of a specific wire by plotting a potential difference against the current graph, and hence its resistivity. Each group received an electronic version of the lab manual. To begin the experiment, pre-service science teachers were supposed to measure and monitor the wire's length and diameter. I was busy observing their interactions as they were busy completing experiments, which helped me understand how real experiments affect interest, confidence, anxiety, or enjoyment in the laboratory. Some of the measurements that were used are measures of ordinal data, meaning responses used ranked order rather than continues scale. Since the assumptions of normality did not met, Levene's test was applied to ordinal data other than the scalar(continues) data. Statistical test such as Kruskal-Wallis test were used to analyse differences between groups(gender), since the data was non-parametric.

Secondly, the findings were acquired after the experiments by administering the post-test to the pre-service teachers. The post-program questionnaire is a self-report instrument

designed to capture the attitudes of pre-service science teachers upon completing their teacher education program. It encompasses a series of structured questions that explore various dimensions of their attitudes towards teaching science. By engaging in this reflective exercise, pre-service teachers could articulate their evolving perspectives and provide valuable feedback for educators and institutions. The questionnaire is an essential tool for assessing the effectiveness of teacher education programs, curriculum development, and the impact of various teaching methodologies.

Lastly, Google Form questionnaires were employed and correctly communicated to 82 pre-service science teachers. The researcher distributed Google forms over the WhatsApp group and then waited for responses. Google Forms is a Google-provided web-based program that allows users to create and distribute surveys, questionnaires, quizzes, and other sorts of online forms. It is a component of Google Workspace, which also contains Google Drive, Google Docs, Google Sheets, and other productivity tools. According to Zainal (2016, p. 285), "Students found typing their responses into Google forms using their smart phones to be easier; and with Google forms, their responses were directly sent to a spreadsheet for easy analysis; and were automatically saved and stored on lecturer's Google drive".

Likert-scale survey questions can be used to evaluate pre-service science teachers attitudes of laboratory experiments. These surveys could include questions about enjoyment, perceived usefulness, confidence, and preferences regarding laboratory experiments. Here's a breakdown of the types of data I will gather based on the survey questions provided:

Enjoyment: Participants rated their level of enjoyment regarding laboratory experiments on a Likert scale. Responses could range from "Strongly Disagree" to "Strongly Agree," with numerical values assigned to each option (e.g., 1 to 5). This data will provide insight into the subjective experience of participants during laboratory activities. Perceived Usefulness: Participants will indicate their perception of the usefulness of laboratory experiments for their learning and future teaching endeavours. Again, responses will be on a Likert scale, allowing participants to express varying degrees of agreement or disagreement regarding the utility of laboratory experiments. Confidence: Participants will

rate their level of confidence in their ability to conduct and facilitate laboratory experiments as future science teachers. Likert-scale questions may assess confidence in specific skills or tasks related to laboratory work, such as setting up equipment, explaining procedures, or troubleshooting issues. Preferences: Participants will express their preferences regarding laboratory experiments, which could include factors such as the types of experiments they enjoy most, preferred teaching methods, or ideal classroom environments for conducting experiments. Likert-scale questions will capture the range of preferences among participants. Once the survey responses are collected, you can analyse the data quantitatively using statistical techniques such as calculating means, standard deviations, and frequency distributions. This analysis will provide insights into the overall attitudes of pre-service science teachers towards laboratory experiments, as well as any trends or patterns in their responses to specific survey items.

As a researcher it will be possible to measure specific behaviours or outcomes related to attitudes, such as participation rates in laboratory sessions, engagement levels, or performance on related assessments. Measuring specific behaviours or outcomes related to attitudes towards laboratory experiments can provide valuable insights into the practical implications of those attitudes. Here's how these measures can contribute to understanding pre-service science teachers' attitudes:

Participation Rates in Laboratory Sessions: This measure assesses the extent to which pre-service science teachers actively engage in laboratory sessions. Higher participation rates may indicate a positive attitude towards laboratory experiments, as participants are willingly involved in hands-on activities and discussions. Conversely, lower participation rates may suggest disinterest or discomfort with laboratory work, potentially reflecting negative attitudes. **Engagement Levels:** as a researcher I can observe and assess the level of engagement displayed by pre-service science teachers during laboratory sessions. Signs of engagement may include active participation, asking questions, interacting with materials, and collaborating with peers. Higher levels of engagement often correlate with positive attitudes towards laboratory experiments, as participants are more likely to be motivated and interested in the learning process. **Performance on Related Assessments:** Assessments related to laboratory experiments, such as quizzes,

practical exams, or project evaluations, can serve as objective measures of participants' understanding, skills, and application of knowledge gained through laboratory activities. Higher performance scores may indicate a strong grasp of concepts and a positive attitude towards engaging with laboratory experiments as effective learning tools.

Data about participants' demographics, such as age, gender, educational background, and prior experiences with laboratory experiments, can provide context for analysing attitudes. Demographic data can provide valuable context for understanding the attitudes of pre-service science teachers towards laboratory experiments. Here's how different demographic factors may influence attitudes:

Age: Age can impact attitudes towards laboratory experiments due to differences in experiences, educational backgrounds, and generational perspectives. Younger pre-service teachers may be more accustomed to interactive and hands-on learning approaches, potentially leading to more positive attitudes towards laboratory experiments compared to older participants. Conversely, older participants may have varying levels of familiarity with laboratory settings and may approach them with different expectations and attitudes.

Gender: Gender can also play a role in shaping attitudes towards laboratory experiments. While attitudes are diverse and individual, there may be societal or cultural influences that impact how individuals perceive laboratory work based on gender stereotypes or expectations. For example, research has shown that gender disparities exist in STEM fields, which may influence how male and female pre-service teachers view laboratory experiences.

Educational Background: Participants' educational backgrounds, including their majors, coursework, and previous academic experiences, can influence their attitudes towards laboratory experiments. Those with stronger backgrounds in science, technology, engineering, and mathematics (STEM) fields may have more positive attitudes towards laboratory work due to familiarity and comfort with scientific concepts and methodologies. Conversely, participants from non-STEM backgrounds may approach laboratory experiments with varying levels of interest and confidence.

Prior Experiences with Laboratory Experiments: Previous experiences with laboratory experiments can significantly impact attitudes towards them. Participants who have had positive experiences in laboratory settings, either through previous coursework, internships, or extracurricular activities, may have

more favourable attitudes towards laboratory experiments. Conversely, participants with negative or limited experiences may worry towards laboratory work.

Choosing a quantitative research approach for studying the attitudes of pre-service teachers towards the use of experiments in teaching and learning science offered several advantages that align with the objectives of the research. Quantitative methods allow for the collection of standardised, numerical data that can be analysed using statistical techniques. This promotes objectivity in data collection and analysis, reducing the potential for bias or subjectivity. Additionally, quantitative research can be easily replicated by other researchers, enhancing the reliability and reproducibility of the study's findings. Quantitative research provides precise measurements of attitudes using Likert-scale questions and other structured survey items. By quantifying attitudes on a numerical scale, I can capture subtle variations in attitudes and perceptions among pre-service teachers, allowing for a more nuanced understanding of the phenomenon under investigation. Quantitative methods enable rigorous statistical analysis of the data, allowing researchers to identify patterns, trends, and relationships among variables. Statistical tests such as correlations, regression analysis, and inferential tests provide quantitative evidence of associations between pre-service teachers' attitudes towards experiments and various demographic or contextual factors. Quantitative research often involves sampling techniques that aim to select a representative sample of the target population. By collecting data from a diverse sample of pre-service teachers across different demographics, educational backgrounds, and geographic locations, researchers can generalize findings to a broader population of pre-service teachers, enhancing the external validity of the study. Quantitative research methods are often more efficient and scalable than qualitative approaches, particularly when dealing with large sample sizes. Surveys and structured questionnaires will be administered to many pre-service teachers simultaneously, allowing researchers to collect data from a sizable and diverse participant pool within a relatively short period. Quantitative research findings provided empirical evidence that can inform policy decisions, educational practices, and curriculum development. By quantifying pre-service teachers' attitudes towards experiments,

researchers can identify areas for intervention, tailor professional development programs, and advocate for evidence-based practices in science education.

Overall, the quantitative research approach is well-suited for investigating the attitudes of pre-service teachers towards the use of experiments in teaching and learning science due to its objectivity, precision, statistical rigor, generalisability, efficiency, and potential impact on educational policy and practice.

There are various approaches for doing quantitative research. Quantitative research can be conducted using the descriptive research technique, correlational, developmental design, observational studies, and survey research. However, correlational, and observational research methodologies will be applied in this study. Williams (2007), for example, "defines correlational as a research method that examines the differences between the two characteristics of the study group". It determines whether two or more variables are connected. This technique will compare the attitudes of pre-service science instructors toward actual and simulated experiments. "In the observational study method, **the** I will observe `a particular aspect of human behaviour with as much objectivity as possible and records the data" (Williams, 2007). In this approach the pre-service science teachers are busy conducting real experiments; I will be examining the attitudes of males and females. There is a lack of empirical evidence on the effects of laboratory experiments on the attitudes of pre-service science teachers regarding experiments.

8. DATA TREATMENT AND ANALYSIS

The analysis tool the researcher used to conduct Inferential and descriptive statistical tests is called IBM-SPSS version 28. SPSS (Statistical Package for the Social Sciences) is a software program that can be used for data analysis on various topics, including the effects of laboratory experiments on pre-service science teachers' attitudes. The analysis included non-parametric tests such as the Chi-Square Test to compare attitudes and identify significant differences across groups. Measures of normality and homogeneity of variances were tested using Levene's Test, Brown-Forsythe Test, and Fligner-Killeen

Test to determine the appropriate statistical procedures. The data were analysed as follows:

Descriptive Statistics: Used to summarise the data like standard deviations and frequency distributions to create frequency tables and bar graphs.

Inferential Statistics: Used to **analyze** the relationship in attitudes of pre-service science teachers, by a test called non-parametric tests (Chi-Square Test).

Assumption Testing: Levene's Test was used to test normality since the data does not meet the normality assumption.

9. ETHICAL CONSIDERATIONS

This section allowed the researcher to ask permission to collect data from the Institution. The research aim is to investigate the attitudes of pre-service science teachers towards the use of experiments in teaching and learning. Participants were asked to provide insights into their experiences, perceptions, and attitudes toward experiments through a structured questionnaire. This study adheres to ethical research principles, ensuring that no harm comes to participants. The research has been reviewed and approved by the relevant Ethics Review Committee (Certificate is attached in Appendix B) to safeguard participants' rights and well-being. **ETHICAL CLEARANCE NO: FHSSE/24/CSEM/22/0509**

1. Permission for inclusion as a participant

At the beginning of the data collection tool, the following was explained. This questionnaire explores the impact of experiments on attitudes towards science and teaching practices, focusing on both hands-on and simulation-based experiments. The responses will provide insight into how different types of experiments influence interest in and the perceived value of science experiments. Completing the questionnaire will take approximately 10 minutes, and all responses will remain confidential and anonymous.

The information collected will be used solely for academic purposes. Participation is voluntary, and individuals may withdraw at any time without any consequences.

2. Anonymity

Anonymity is a type of ethical consideration whereby participants' identity information is kept private. In this research, no personal information was shown. Data was collected using Google Forms, which allows participants to answer questions without being linked to any personal information. After collection, the data was stored where only the researcher and supervisor accessed it. By not revealing participants' personal information, the study respects ethical research standards and makes participants to respond with true thought.

3.9.3 Confidentiality

All data collected will be kept confidential and will only be used for research purposes. The findings were collected in such a way that no individual responses could be traced back to specific participants. The results on the Google Form were only reachable by the researcher and academic supervisor for analysis and interpretation of data. The confidentiality process promotes confidence in participants and encourages truthful participation in the study.

3.9.4 Rights of participants

Participants in this study were informed of their rights before their involvement. These rights include:

- Voluntary Participation: It is the choice of participants to choose whether to participate in the study or not.
- Informed Consent: All participants were informed about the purpose of the study and their rights before volunteering to participate.
- Confidentiality and Anonymity: No personal information was collected, and participants' responses were kept confidential.
- Right to Withdraw: Participants had the right to withdraw at any time.

These measures ensured that ethical considerations were met and that participants' rights were protected throughout the research process.

5. Informed consent

In this study, all participants provided informed consent before participation to ensure ethical research practices. Participants were given a clear explanation of the study's purpose, objectives, and procedures through writing.

This process ensured that participants fully understood their involvement in the study and contributed voluntarily, in accordance with ethical research guidelines.

10. MEASURES OF QUALITY CONTROL

Quantitative research (Reliability and Validity)

Validity- is referred to how accurate a technique is needed to evaluate. To guarantee validity, pilot study might be used before the researcher collect final results. Pilot study is employed in order to improve questions and test whether the questions provided are liable. Before giving the respondents actual survey, the researcher takes on a pilot study to produce improved version of the questionnaires. Although the results of pilot study might be a replication of the actual sample. Furthermore, the researcher uses primary data collection method to test for validity. The incomplete surveys collected in pilot study will be identified as rejected paper and will be excluded from the data analysis. Secondary data obtained from reliable sources will be used to ensure validity and it will also assist the researcher in understanding the study related to that data. The following will help in maintaining validity in quality control measures:

Content Validity: According to Straub et al. (2004), p. 424, content validity is "the extent to which items in an instrument reflect the content universe to which the instrument will be **generalised.**" Applying content validity is highly advised in the field of Information Systems while a new instrument is being created.

A new survey instrument is often evaluated for content validity to make sure it has all the necessary questions and omits those that are not relevant to a specific construct domain (Lewis et al., 1995; Boudreau et al., 2001).

Criterion-Related Validity: According to Taherdoost (2016), the amount to which a measure is connected to an outcome is referred to as criterion or concrete validity. It assesses how accurately one measure predicts the result of another. This sort of validity

applies to a test if it can predict performance or behavior in a different circumstance (past, present, or future).

Criterion validity is a different viewpoint that downplays the conceptual meaning or interpretation of test results. Users may simply want to utilize a test to distinguish between groups of individuals or to forecast future results (Taherdoost., 2016). For example, if you are looking at changes in students' attitudes toward science, compare your results to known attitude scales to ensure consistency.

Construct Validity: According to Taherdoost (2016), construct validity relates to how successfully you translated or changed a construct-based notion, idea, or behaviour into a working and operational reality, or operationalization. Use tools such as factor analysis to ensure that the items are loaded into the predicted components expressing attitudes toward science investigations.

Reliability- refers to how consistently a method measures something. To ensure the reliability of the information gathered, the researcher will use approved data collection methods and techniques such as questionnaires, experiments and observations. This measurement technique is accurate and repeatable. To ensure the accuracy of the data collected, the researcher will use legal data-gathering techniques, such as surveys and experiments.

The test-retest procedure evaluates the consistency of measurements across time. It entails repeating the same experiments on the same students at different times and then evaluating the relationship between the findings. When carrying out scientific experiments with students, many methods will be utilized to examine how the science experiments change their attitudes. The Pre-experiment assessment is carried out before the experiment to measure the attitudes of pre-service science teachers about the various types of experiments. The experiment that the students will do will be relevant to the subject matter covered in the scientific curriculum. After the experiment, the post-experiment evaluation will be given to review the students' opinions using the same measuring instruments as previously. By using internal consistency reliability measures, one can gain insight into how consistent your measurement instrument is in assessing

changes in students' attitudes as a result of the science experiments. This helps ensure that the results of the science experiments are accurately reflected in the results of the questionnaires.

Inter-Rater Reliability: This is important when there are numerous raters or observers engaged. It measures the degree of agreement among raters while assessing the same phenomena. Parallel Forms Reliability According to Carmines and Zeller (1979), reliability is the degree to which a measurement of a phenomena yields a steady and consistent response. Repeatability is another aspect of reliability. For instance, a scale or test is considered dependable if it consistently produces the same result when repeated measurements are conducted (Moser and Kalton, 1989). If the measure is accurate, the scores from both forms should be significantly connected.

When constructing studies to measure the effects of scientific investigations on students' attitudes, parallel form's reliability is critical. It contributes to ensuring that the measuring equipment employed is dependable and that any apparent changes in attitudes are more likely attributable to experimental manipulation than to measurement mistakes. The use of parallel forms reliability reduces the possibility of bias caused by students growing familiar with the survey questions and responding differently in successive administrations. It also helps researchers to take measurement errors into account when analysing variations in attitude ratings across groups.

The experiments will be prepared and conducted by the researcher and demonstrator before the actual day of the experiments with the pre-service science teachers to test accuracy. Therefore, the pilot study will allow the researcher to test the data collection tool. The pilot test will be conducted in the selected experiments, where the researcher will conduct real experiments and observations with demonstrators. Thus, it may be stated that dependability can be described as the relationship between what a researcher records as data and what happens in the classroom setting that is being investigated.

11. TRUSTWORTHINESS

Ensuring trustworthiness in this study was essential to maintain the credibility, reliability, and validity of the research findings. The study adhered to the following principles of trustworthiness:

Credibility: The study used tried-and-true techniques for gathering and analyzing data, such as structured questionnaires and IBM-SPSS statistical analysis. Multiple statistical tests were used to ensure triangulation and confirm the consistency of the results.

Dependability: To guarantee consistency, a systematic and repeatable study design was used. Because the study's methodology was well recorded, it may be repeated by other researchers in comparable settings.

Confirmability: By guaranteeing that results were obtained directly from participant responses free from researcher bias, the study preserved impartiality. All judgments were supported by quantifiable evidence, and data analysis followed methodical statistical techniques.

Transferability: By providing a thorough explanation of the population, sampling strategy, and research context, the study enables future researchers to assess if the results are applicable in different contexts. By following these steps, this study increases the reliability and promotes the integrity of the research process.

12. SUMMARY

This chapter covered ethical guidelines to ensure the protection and safety of all participants. The ethical principles such as informed consent, confidentiality and anonymity, voluntary participation and ethical approval (The researcher received ethical certificates from the Institution, the study complied with institutional ethical guidelines and received approval from the relevant Ethics Committee) were explained in this chapter. By following these ethical considerations, the study ensured the integrity of the research process and the protection of participants' rights.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

1. INTRODUCTION

The analysis in this study focuses on examining the attitudes of pre-service teachers towards the use of experiments in science education. The data collected is ordinal in nature, gathered through structured questionnaires that used Likert-scale responses to measure attitudes. Given the ordinal data and the likelihood of non-normal distribution, non-parametric tests were employed. These tests are suitable for comparing medians and distributions without assuming a normal distribution, making them ideal for the study's data characteristics.

The primary groups compared in this analysis are based on gender (male and female pre-service teachers), exploring whether conducting experiments helps in developing scientific skills and attitudes, gender-related attitudes influence choices between real and simulated experiments and also the availability of resources when choosing between real and simulated experiments. The Independent-Samples Median Test and the Kruskal-Wallis Test were used to compare medians and distributions across gender categories, allowing for a robust analysis of potential differences in attitudes and preferences.

2. DESCRIPTION OF THE STATISTICAL TEST

In this study, a non-parametric statistical test called Kruskal-Wallis Test, was employed to analyse the attitudes of pre-service teachers towards the use of experiments in science education. The Kruskal-Wallis Test was designed to compare the distributions of a dependent variable (conducting whether experiments help in developing scientific skills and attitudes, gender-related attitudes influence choices between real and simulated experiments and also the availability of resources when choosing between real and simulated experiments) across the gender. In this case, it was used to determine whether there were significant differences in attitudes based on gender (male and female pre-service teachers).

The Kruskal-Wallis Test assesses whether the median ranks of the groups are significantly different, without assuming a normal distribution of the data. It is considered non-parametric data and is particularly useful for ordinal data or data that violate the assumptions required for parametric tests.

Figure 4.1: General Information about Pre-Service Teachers

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	36	43,9	43,9	43,9
	Female	46	56,1	56,1	100,0
	Total	82	100,0	100,0	

The Cronbach's Alpha on **Figure 4.2** below, shows the high level of internal consistency. Based on 19 items, the Cronbach's Alpha coefficient for the questionnaire was 0.878. this is the mark to shows that the items in the questionnaire are strongly correlated, and they measure the same underlying construct effectively. everything in the items appear necessary and the score suggest that the instrument is well-structured this result implies that questionnaires that were used are valid tool for assessing pre-service science teachers attitudes towards experiments in science education.

Figure 4.2: Cronbach's Alpha

Reliability Statistics	
Cronbach's Alpha	N of Items
,878	19

3. REPORTING THE RESULTS

The Case Processing Summary below (**Figure 4.3**) provides an overview of the dataset, and the number of valid cases used in the analysis.

Both Gender * Preference for Real Experiments over Simulations:

Valid Cases= 82 (100% of the data points in this variable are valid, with no missing data).

Missing Cases= 0 (there are no missing values in this variable).

Total Cases: 82 (total number of observations).

Both Gender * Preference for Simulations over Real Experiments:

Valid Cases= 82 (100% of the data points in this variable are valid, with no missing data).

Missing Cases= 0 (there are no missing values in this variable).

Total Cases= 82 (total number of observations).

The analysis had 82 valid responses for both the variables concerning gender and preferences for real versus simulated experiments. There were no missing data points, so all the observations were included in the analysis. This suggests that the dataset was complete and there were no issues with missing information for these specific variables.

Figure 4.3: Case Processing Summary

Case Processing Summary						
	Valid		Cases Missing		Total	
	N	Percent	N	Percent	N	Percent
Gender * PreferenceForRealExperimentsOverSimulations	82	100,0%	0	0,0%	82	100,0%
Gender * PreferenceForSimulationsOverRealExperiments	82	100,0%	0	0,0%	82	100,0%

The Descriptives Table (**Table 4.1**) (APPENDIX C) provides a summary of the statistical measures for the three variables (availability of resources when choosing between real and simulated experiments, gender-related between real and simulations as well as conducting experiments helps develop scientific skills and attitudes).

The descriptive statistics for male and female pre-service teachers reveals differences in their attitudes towards experiments in science education, focusing on median as key indicator of central tendency.

Interpretation of results:

For the research question "To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?", the median for males is 4.50, while for females, it is slightly higher at 5.00, indicating that females tend to agree more strongly with this statement.

For the research question "To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?", both males and females share the same median of 3.00, indicating a neutral stance on the influence of gender-related differences.

For the research question "What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?", males have a median of 4.00, whereas females again show a higher median of 5.00, suggesting that females lean more towards favouring availability when choosing between real experiments and simulations.

Overall, while females generally exhibit higher medians, indicating stronger agreement with positive statements about experiments. Males, on the other hand, tend to have slightly lower medians and more consistent responses.

The Chi-Square Test results below (**Figure 4.4**) provide insights into whether there is a significant relationship between gender and preference for real experiments over simulations. Here's a breakdown of the results:

Pearson Chi-Square:

- Value: 14.408
- Degrees of Freedom (df): 4
- Asymptotic Significance (2-sided): 0.006 (p-value)

The Pearson Chi-Square interpret that the p-value for the Pearson Chi-Square test is 0.006, which is less than the commonly used significance level of 0.05. This indicates that there is a significant association between gender and preference for real experiments over simulations. In other words, gender does have an influence on the preference for real versus simulated experiments.

Likelihood Ratio:

- Value: 15.432
- Degrees of Freedom (df): 4
- Asymptotic Significance (2-sided): 0.004 (p-value)

The Likelihood Ratio interpret that the p-value for the likelihood ratio is 0.004, also less than 0.05, supporting the result from the Pearson Chi-Square test. This suggests that the likelihood ratio test also detects a significant relationship between gender and the preference for real experiments.

Linear-by-Linear Association:

- Value: 8.706
- Degrees of Freedom (df): 1
- Asymptotic Significance (2-sided): 0.003 (p-value)

The Linear-by-Linear Association interpret that the p-value for the linear-by-linear association is 0.003, which is also significant. This test evaluates the directionality of the association between the variables, confirming that there is a trend or ordered relationship between gender and preference for experiments.

In conclusion, the Chi-Square test results indicate a significant relationship between gender and preference for real experiments over simulations. Since the p-value is less than 0.05, we reject the null hypothesis, concluding that gender significantly influences the preference for real versus simulated experiments. Number of cases is equal to 82.

Figure 4.4: Chi-Square Test

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14,408 ^a	4	,006
Likelihood Ratio	15,432	4	,004
Linear-by-Linear Association	8,706	1	,003
N of Valid Cases	82		

a. 3 cells (30,0%) have expected count less than 5. The minimum expected count is 3,51.

The Symmetric Measures Figure below (**Figure 4.5**) provide additional insights into the strength and significance of the relationship between the two nominal variables: gender and preference for real experiments over simulations. The significant values (p-value = 0.006) for both Phi and Cramer's V confirm that there is a moderate to strong association between gender and preference for real experiments over simulations. Since both tests show significance, we can conclude that the relationship between gender and preference for experiments is not only present but also statistically significant.

Figure 4.5: Symmetric Measures

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	,419	,006
	Cramer's V	,419	,006
N of Valid Cases		82	

4.3.1. TESTING EQUALITY USING LEVENE'S TEST

I tested equality by conducting Levene's test. The following three attitudes score were used:

- Compare availability of resources when choosing between real and simulated experiments (Research question 3)
- Gender preferences between real and simulation (Research question 2)
- Conducting experiments helps develop scientific skills and attitudes (Research question 1).

Key Information:

- Levene Statistic: The test statistic for Levene's test.
- df1 and df2: Degrees of freedom for the test.
- Sig. (p-value): Indicates whether the variances are equal.

Interpretation Guidelines:

- If $p > 0.05$: Fail to reject the null hypothesis, indicating that the variances are equal (homogeneity of variances is met).
- If $p \leq 0.05$: Reject the null hypothesis, indicating that the variances are not equal (homogeneity of variances is violated).

The **Figure 4.6** below shows the results of independent t-test used to test normality. The results are as follows:

FOR LEVENE'S TEST

For the research question 1: "To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?"

- $F=0.484$, $\text{Sig.}=0.488$, since the p-value is greater than 0.05, the equal variances is then assumed.

For the research question 2: " To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?"

- $F=0.090$, $\text{Sig.}=0.764$. since the p-value (Sig.) is greater than 0.05, equal variances are assumed.

For the research question 3: " What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?",

- $F=0.964$, $\text{Sig.}=0.329$, which is greater than 0.05 and we assume equal variances. Levene's Test results show that for all three variables, variances are equal (since $p > 0.05$)

FOR T-TEST

For the research question 1: "To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?"

- $t = -0.189$, $\text{Sig. (two-tailed)} = 0.851$, which is not significant since p-value is greater than 0.05.

For the research question 2: " To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?"

- $t = -0.364$, $\text{Sig. (two-tailed)} = 0.717$, since the p-value is greater than 0.05, then the results is not significant.

For the research question 3: " What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?",

- $t = -0.114$, $\text{Sig. (two-tailed)} = 0.910$, since the p-value is greater than 0.05, then the results is not significant.

t-test results show that all three variables have no significant difference between groups

Since all the p-values(sig.) is greater than 0.05, then the **homogeneity of variances is violated.**

Figure 4.6: Independent Sample Test

Independent Samples Test											
		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						One-Sided p	Two-Sided p			Lower	Upper
ConductingExperimentsHelpsDevelopScientificSkillsAndAttitudes	Equal variances assumed	,484	,488	-,189	80	,425	,851	-,062	,326	-,710	,587
	Equal variances not assumed			-,191	77,688	,425	,849	-,062	,323	-,705	,581
GenderRelatedAttitudesInfluenceChoicesBetweenRealAndSimulated	Equal variances assumed	,090	,764	-,364	80	,358	,717	-,110	,302	-,711	,491
	Equal variances not assumed			-,364	75,732	,358	,717	-,110	,302	-,711	,491
AvailabilityWhileChoosingBetweenRealOrSimulations	Equal variances assumed	,964	,329	-,114	80	,455	,910	-,036	,319	-,671	,598
	Equal variances not assumed			-,116	79,024	,454	,908	-,036	,313	-,660	,588

For the research question 1: “To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?”

The test statistic results show that:

$H=0.347$), $df=1$ and the p-value (Asymptotic Sig.) is 0.556.

Based on **Figure 4.7** below the p-value (0.556) exceeds the alpha level of 0.05. Based on the Kruskal-Wallis H Test, it is discovered that there is no significant difference in attitudes toward conducting experiments between male and female pre-service teachers.

Figure 4.7: Independent- Sample Kruskal-Wallis Test Summary (for conducting experiments helps develop scientific skills and attitudes)

Independent-Samples Kruskal-Wallis Test Summary	
Total N	82
Test Statistic	,347 ^{a,b}
Degree Of Freedom	1
Asymptotic Sig.(2-sided test)	,556

a. The test statistic is adjusted for ties.
b. Multiple comparisons are not performed because there are less than three test fields.

For the research question 2: " To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?"

The test statistic results show that:

$H=0.082$), $df=1$ and the p-value (Asymptotic Sig.) is 0.774

Based on **Figure 4.8** below the Kruskal-Wallis H Test has a p-value of 0.774 which is greater than 0.05.in conclusion, there is no significant difference in whether gender-related attitudes affect preferences between real and simulation experiments.

Figure 4.8: Independent- Sample Kruskal-Wallis Test Summary (for gender-related attitudes influence choices between real and simulation experiments)

**Independent-Samples Kruskal-Wallis Test
Summary**

Total N	82
Test Statistic	,082 ^{a, b}
Degree Of Freedom	1
Asymptotic Sig.(2-sided test)	,774

a. The test statistic is adjusted for ties.

b. Multiple comparisons are not performed because there are less than three test fields.

For the research question 3: " What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?",

The test statistic results show that:

$H=0.247$, $df=1$ and the p-value (Asymptotic Sig.) is 0.619

Based on **Figure 4.9** below the Kruskal-Wallis H Test discovered that there is no significant difference in the availability of resources when choosing between real and simulation experiments, because the p-value is 0.619, and it exceeds the alpha level of 0.05.

Figure 4.9: Independent- Sample Kruskal-Wallis Test Summary (for the availability of resources when choosing between real and simulation experiments)

**Independent-Samples Kruskal-Wallis Test
Summary**

Total N	82
Test Statistic	,247 ^{a, b}
Degree Of Freedom	1
Asymptotic Sig.(2-sided test)	,619

a. The test statistic is adjusted for ties.

b. Multiple comparisons are not performed because there are less than three test fields.

3. INTERPRETATION OF THE RESULTS

Figure 4.10: Hypothesis Test Summary

Hypothesis Test Summary				
Null Hypothesis		Test	Sig. ^{b,c}	Decision
1	The medians of ConductingExperimentsHelpsDevelopScientificSkillsAndAttitudes are the same across categories of Gender.	Independent-Samples Median Test	. ^a	Unable to compute.
2	The medians of AvailabilityWhileChoosingBetween nRealOrSimulations are the same across categories of Gender.	Independent-Samples Median Test	,504 ^d	Retain the null hypothesis.
3	The medians of GenderRelatedAttitudesInfluence ChoicesBetweenRealAndSimulat ed are the same across categories of Gender.	Independent-Samples Median Test	,960 ^d	Retain the null hypothesis.

a. All test field values are less than or equal to the median.

b. The significance level is ,050.

c. Asymptotic significance is displayed.

d. Yates's Continuity Corrected Asymptotic Sig.

For the research question 1: “To what extent do pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes?”

Results: unable to compute, reason (see **Figure 4.10** above).

Practical Implications: Pre-service teachers' views on the value of experiments in developing scientific knowledge are not greatly influenced by gender, therefore teacher preparation programs may use consistent methods to encourage experimental learning without having to adjust their methods according to a student's gender. This conclusion highlights that both male and female pre-service teachers appreciate hands-on experiments equally, which is consistent with the movement towards gender-neutral pedagogical techniques in scientific education.

Figure 4.11: Independent sample Median Test Summary (for gender-related attitudes influence choices between real and simulation experiments)

Independent-Samples Median Test Summary

Total N		82
Median		3,000
Test Statistic		,032 ^a
Degree Of Freedom		1
Asymptotic Sig.(2-sided test)		,858
Yates's Continuity Correction	Chi-Square	,003
	Degree Of Freedom	1
	Asymptotic Sig.(2-sided test)	,960

a. Multiple comparisons are not performed because there are less than three test fields.

For the research question 2: " To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?"

Result: Not significant; null hypothesis taken ($p = 0.960$).

Practical Implications: The findings in **Figures 4.10 and 4.11** above imply that pre-service teachers are unaware of the role gender plays in affecting their choices between simulated and real experiments. This suggests that both male and female teachers are equally prepared to use various kinds of teaching resources, which may represent a favourable cultural change in scientific education toward gender equality. Teachers should, however, continue to be mindful of such unconscious biases and make sure that classroom dynamics encourage fair participation in both real and simulated laboratory exercises.

Figure 4.12: Independent sample Median Test Summary (for the availability of resources when choosing between real and simulation experiments)

Independent-Samples Median Test Summary

Total N	82
Median	4,500
Test Statistic	,792 ^a
Degree Of Freedom	1
Asymptotic Sig.(2-sided test)	,373
Yates's Continuity Correction	Chi-Square
	Degree Of Freedom
	Asymptotic Sig.(2-sided test)
	,446
	1
	,504

a. Multiple comparisons are not performed because there are less than three test fields.

For the research question 3: "What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?",

Result: **Figure 4.10 and Figure 4.12** above shows $p = 0.504$ (Not significant; null hypothesis retained).

Practical Implications: It appears that both male and female pre-service teachers appreciate having access to both real and virtual experiments, as seen by the lack of a significant gender difference. This suggests that mixed-learning strategies, which combine simulations with real-world experiments, are widely recognized and may eventually become common in scientific courses. Because simulation technology and physical lab resources are equally accessible to all pre-service teachers, regardless of gender, educational policymakers and curriculum writers may invest in these resources with confidence.

4. VISUAL REPRESENTATION

Research Question 1: Are there significant gender differences in attitudes toward the statement, "Conducting experiments helps develop scientific skills and attitudes"?

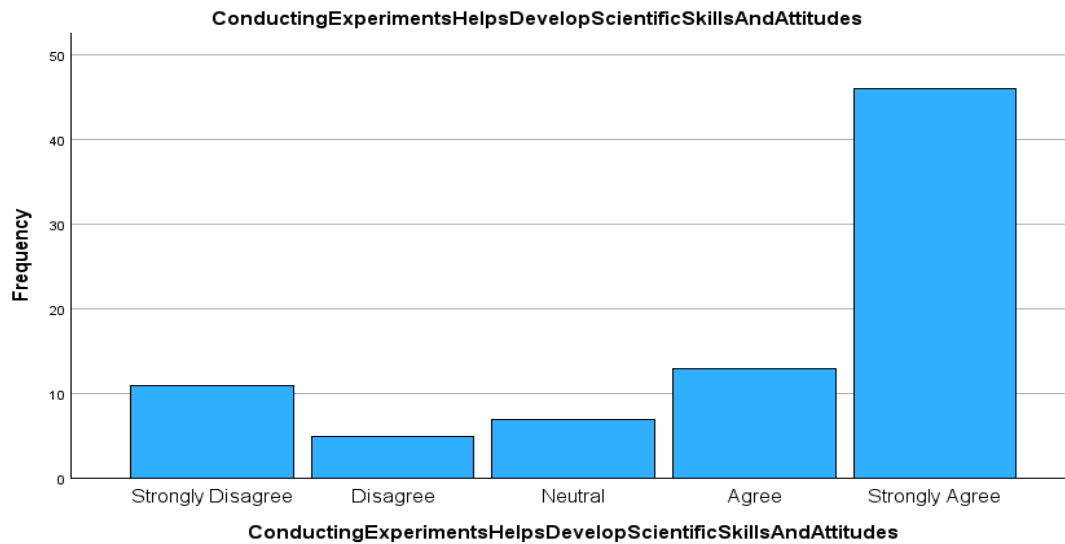
The **Table 4.2** and bar graph (**Figure 4.13**) below show that many pre-service teachers strongly agree that conducting experiments helps develop scientific skills and attitudes. However, 46 participants strongly agree, while 11 participants strongly disagree. It is concluded that most pre-service teachers identify the importance of experiments in developing scientific skills and attitudes.

Table 4.2: Frequency Table (for conducting experiments helps develop scientific skills and attitudes)

ConductingExperimentsHelpsDevelopScientificSkillsAndAttitudes

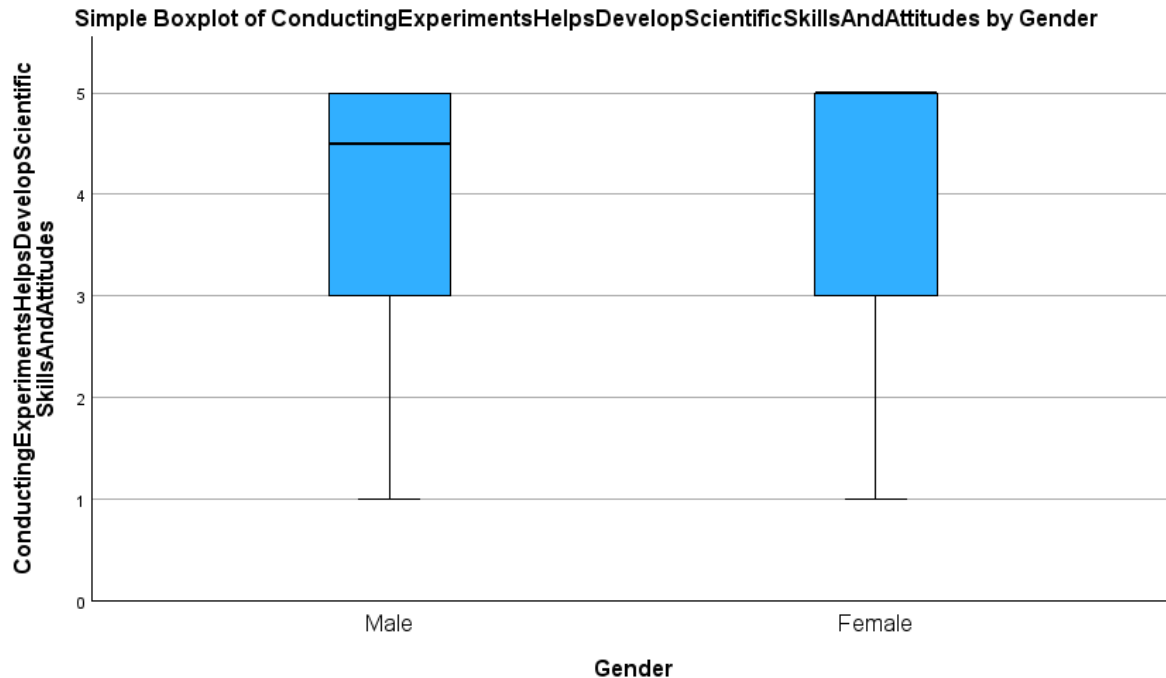
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	11	13,4	13,4	13,4
	Disagree	5	6,1	6,1	19,5
	Neutral	7	8,5	8,5	28,0
	Agree	13	15,9	15,9	43,9
	Strongly Agree	46	56,1	56,1	100,0
	Total	82	100,0	100,0	

Figure 4.13: Frequency Bar Graph (for conducting experiments helps develop scientific skills and attitudes)



The boxplot (**Figure 4.14**) below indicates that there is no significant difference in the age distribution between male and female pre-service teachers regarding their attitudes toward conducting experiments in science education. It is then concluded that age doesn't affect the attitudes of pre-service teachers in developing scientific skills and attitudes.

Figure 4.14 Box Plot (for conducting experiments helps develop scientific skills and attitudes)



For the research question 2: " To what extent does gender affect the preferences of Pre-Service science teachers when deciding between real and simulated experiments in science education programs?"

The views of male and female pre-service teachers about the use of real experiments vis-a-vis simulations in scientific instruction are compared in this crosstabulation (**Table 4.3**) and bar graph (**Figure 4.15**). The total number of responses for each gender is given, and the opinions are grouped from Strongly Disagree to Strongly Agree.

Strongly Disagree: More females have negative attitudes towards using real or simulated experiments (14 females strongly disagree compared to 10 males).

Disagree: 6 females disagreed compared to 4 males.

Neutral: 9 males were neutral compared to 7 females. This gives the conclusion that males showed a slightly higher tendency to be neutral towards this decision.

Agree: Both genders have an equal number of participants (8) who agree. This suggests a shared positive attitude across genders.

Strongly Agree: 11 females strongly agreed compared to 5 males. Females were more likely to strongly support the use of real or simulated experiments.

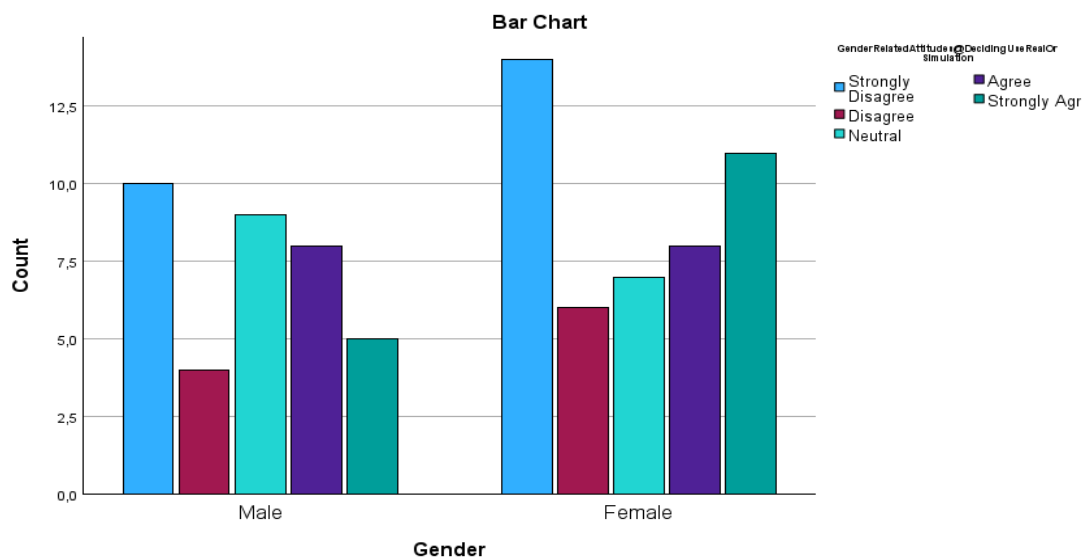
Table 4.3: Crosstab (for gender-related attitudes influence choices between real and simulation experiments)

**Gender * GenderRelatedAttitudes@DecidingUseRealOrSimulation
Crosstabulation**

Count

		GenderRelatedAttitudes@DecidingUseRealOrSimulation					
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Gender	Male	10	4	9	8	5	36
	Female	14	6	7	8	11	46
Total		24	10	16	16	16	82

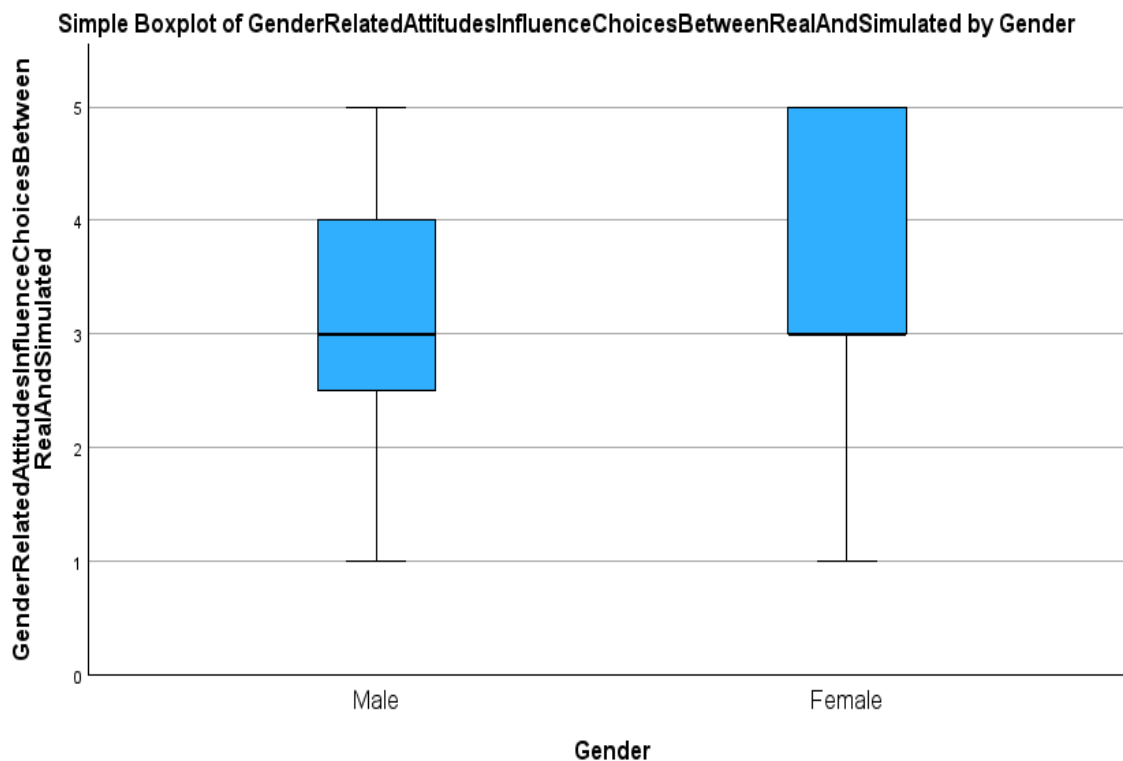
Figure 4.15: Frequency Bar Graph (for gender-related attitudes influence choices between real and simulation experiments)



The distribution of responses from male and female pre-service teachers about the resources available when deciding between simulations and real experiments in scientific education is shown in the boxplot (**Figure 4.16**) below. When deciding between real

experiments and simulations, there is a small gender-based variation in perceptions of resource availability, according to the boxplot in **Figure 4.16** The median, interquartile range, and range of responses for male and female pre-service teachers are comparable, indicating that opinions toward the availability of experimental resources in scientific education are not significantly influenced by gender.

Figure 4.16: Box Plot (for gender-related attitudes influence choices between real and simulation experiments)



For the research question 3: "What factors such as resource availability, may influence the frequency of pre-service teachers' use of simulations or real experiments at high school-level education?",

Table 4.4 and **Figure 4.17** below show the results for "Availability of Resources While Choosing Between Real or Simulations", 41 (50.0%) participants strongly agree, and 14 (17.1%) agree. This indicates that many pre-service teachers prefer having options between real experiments and simulations. These findings conclude that there is a

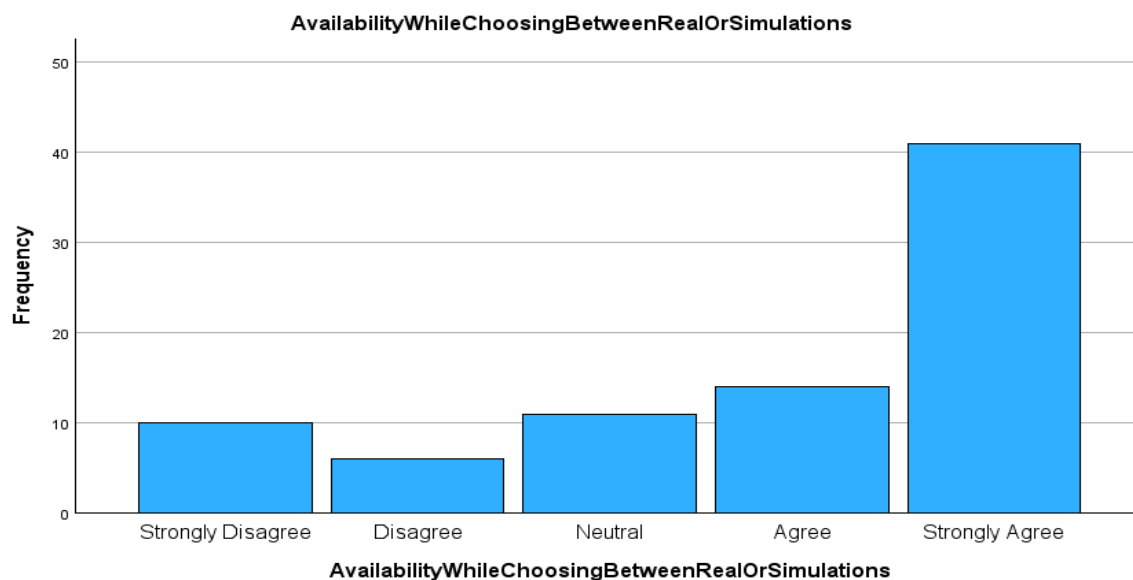
significant minority who disagree with the statement, and half of the participants agree.



Table 4.4 Frequency Table (for the availability of resources when choosing between real and simulation experiments)

AvailabilityWhileChoosingBetweenRealOrSimulations					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	10	12,2	12,2	12,2
	Disagree	6	7,3	7,3	19,5
	Neutral	11	13,4	13,4	32,9
	Agree	14	17,1	17,1	50,0
	Strongly Agree	41	50,0	50,0	100,0
	Total	82	100,0	100,0	

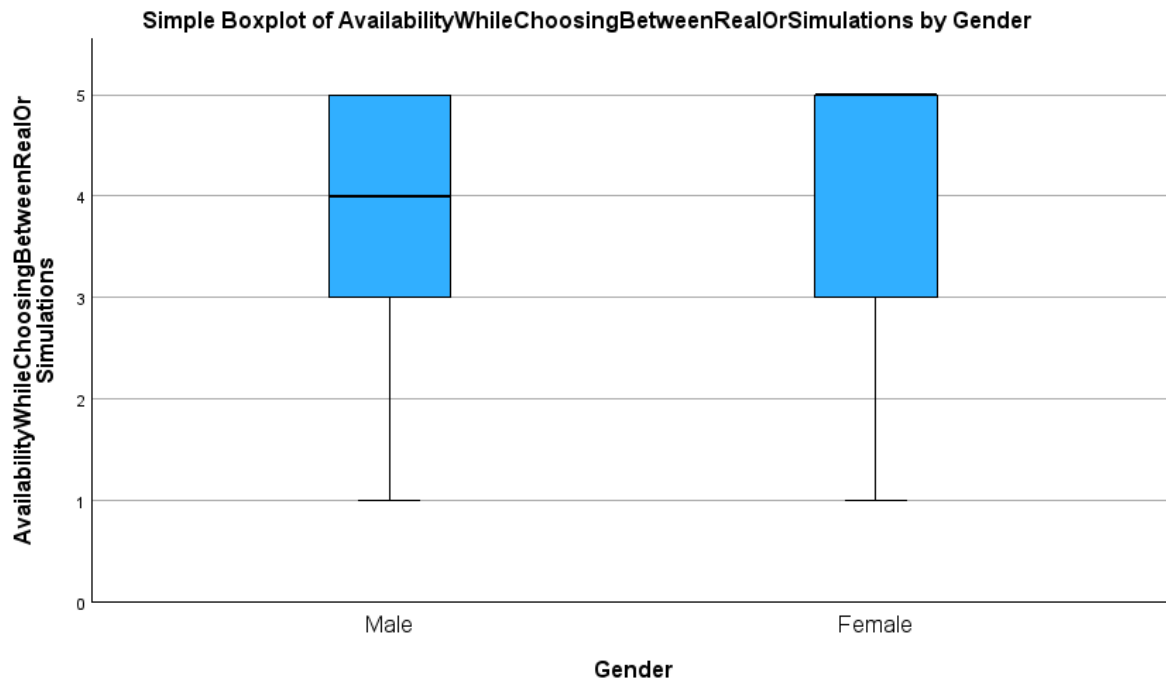
Figure 4.18: Frequency Bar Graph (for the availability of resources when choosing between real and simulation experiments)



The boxplot in **Figure 4.18** indicates that both genders share the same median which suggests that age does not affect how pre-service teachers perceive the role of experiments in developing scientific skills and attitudes. It is then concluded that there is

no substantial difference in the age distribution between male and female pre-service teachers regarding their attitudes toward conducting experiments in science education.

Figure 4.18: Box Plot (for the availability of resources when choosing between real and simulation experiments)



5. LIMITATIONS AND RECOMMENDATIONS

A key limitation of this study is its support on non-parametric tests, which, while appropriate for the ordinal data, may lack the sensitivity to detect subtle differences between groups. Additionally, the sample size, though adequate, was limited to pre-service teachers from a single university, potentially affecting the generalizability of the findings. The focus on gender as the primary variable may have overlooked other influential factors such as prior educational experiences, access to resources, or cultural influences.

Practical Implications: The study's findings imply that pre-service teachers' opinions about the use of experiments in science education are not substantially influenced by gender. In particular, the Kruskal-Wallis H Test revealed that pre-service teachers' opinions on

"Availability While Choosing Between Real or Simulations," "Conducting Experiments Helps Develop Scientific Skills and Attitudes," and "Gender-Related Attitudes Influence Choices Between Real and Simulated" did not differ significantly between male and female pre-service teachers (all p-values greater than 0.05). Male and female pre-service teachers had identical opinions in these conditions, indicating that gender is not a determining factor in developing attitudes toward these areas of scientific teaching.

In terms of practical implications, these results suggest that interventions or teaching strategies aimed at promoting experimental learning in science education can be designed without considering gender differences.

Relation to Existing Literature: The results of this study are partly in line with previous research that indicates gender differences in attitudes toward science education are typically negligible or non-existent in many settings, particularly in more recent times. According to earlier studies, pre-service teachers' views may be more influenced by characteristics including prior scientific education, educational background, and past experiences than by gender. These findings support the broader theoretical expectation that educational interventions should be created to meet individual learning needs rather than gender-specific expectations, as gender does not necessarily shape perceptions of science learning and teaching (Bazi, 2010, p. 145).

Moreover, the results contrast with some older studies that have suggested gender-related differences in attitudes toward science, where males were sometimes found to be more confident or interested in practical science activities. However, as gender roles in science education become more equitable and inclusive, these differences are diminishing, as shown in the present study.

6. SUMMARY

The findings indicate that gender does not influence attitudes towards conducting experiments, since all p-values are greater than 0.05. It is then concluded that none of the differences between male and female pre-service teachers' attitudes are statistically significant. This suggests that gender does not play a significant role in shaping these

attitudes. However, several limitations must be acknowledged. The study focused solely on gender differences, potentially overlooking other influential factors such as prior educational experiences, access to laboratory resources, or cultural influences, which may significantly impact attitudes towards experiments.

1. Practical Implications and limitations of the study:

Gender-neutral approach: Based on gender-specific attitudes, no noticeable differences were found in gender. Science teachers can use teaching strategies without modifying them.

Further research: Future studies should consider other factors such as past educational experiences to examine how attitudes may be influenced by other factors, even if no gender differences were discovered.

CHAPTER 5: SUMMARY, CONCLUSION, RECOMMENDATIONS

1. SUMMARY

This study investigated the attitudes of male and female pre-service teachers toward conducting experiments in science education, focusing on their preferences between real and simulated experiments and how gender-related attitudes influence these choices. Using non-parametric statistical methods, specifically the Kruskal-Wallis's test, the analysis revealed that there were no statistically significant differences between male and female participants in any of the measured attitudes. Boxplot visualizations supported these findings, showing similar median scores and overlapping interquartile ranges across genders. These results suggest a consistent, gender-neutral perspective among pre-service teachers regarding the value of experiments in developing scientific skills and attitudes.

2. INTERPRETATION OF RESULTS

The results of this study indicate that there are no statistically significant differences in the attitudes of male and female pre-service teachers towards conducting experiments in science education. This conclusion is supported by the fact that all p-values derived from the non-parametric Kruskal-Wallis tests were greater than 0.05, suggesting that gender does not significantly influence how pre-service teachers perceive the value of experiments in developing scientific skills and attitudes. The boxplots further reinforce these findings, showing similar median scores for both genders across various attitude measures, with only slight variations in the interquartile ranges. This consistency in responses suggests a generally uniform perception of the importance of experiments, regardless of gender.

In addition to attitudes toward conducting experiments, the study also explored gender differences in preferences between real and simulated experiments and the influence of gender-related attitudes on these choices. Again, the results showed no significant differences between male and female pre-service teachers. Both groups exhibited similar distributions in their responses, as indicated by overlapping interquartile ranges in the boxplots and consistent median values. This suggests that both male and female pre-service teachers value the availability and use of both real and simulated experiments similarly, and their choices are not significantly influenced by gender-related attitudes.

These findings imply that gender is not a determining factor in shaping pre-service teachers' attitudes towards experimental science education. This could reflect a broader trend of gender-neutral perspectives in science education, potentially driven by equal access to educational resources and opportunities in teacher training programs. However, while gender does not appear to play a significant role, other factors not explored in this study (such as prior educational experiences, cultural influences, or access to laboratory resources) may still affect attitudes and should be considered in future research.

3. CONCLUSIONS

The findings of this study indicate that gender does not significantly influence pre-service teachers' attitudes toward conducting experiments or their preferences between real and simulated experiments. Both male and female pre-service teachers demonstrated similar attitudes, highlighting a gender-neutral approach in their perceptions of science education practices. However, other factors, such as prior educational experiences, access to resources, or cultural influences, may play a more significant role in shaping these attitudes. The absence of significant gender differences implies that teacher training programs can adopt uniform strategies for all pre-service teachers, focusing on enhancing experimental skills and engagement without the need for gender-specific adaptations.

4. RECOMMENDATIONS

Adopt Gender-Neutral Teaching Strategies: Since there aren't many notable differences in gender, curriculum designers and science educators should concentrate on developing inclusive, gender-neutral teaching strategies that highlight the value of experiments in science education for all students.

Explore Additional Influencing Factors: Future studies should look into additional factors such as past educational experiences, access to laboratory resources, and cultural or socioeconomic backgrounds that may have an impact on pre-service teachers' opinions. A deeper understanding of what influences attitudes toward experiments in scientific education may be possible, thanks to these characteristics.

Expand the Study Scope: Future research should use bigger, more varied samples from a cross-section of teacher education institutions and regions to improve the findings' generalizability. This would offer a more comprehensive picture of the views of pre-service teachers in various settings.

Incorporate Mixed-Methods Strategies: Future studies that combine quantitative and qualitative methodologies may provide a more thorough knowledge of the variables affecting attitudes. Interviews and focus groups are examples of qualitative data that may reveal complex viewpoints that are not always visible through quantitative analysis.

Longitudinal Studies: Longitudinal studies that monitor the attitudes of pre-service teachers over time, especially as they go through their training and into their teaching careers, would yield important information on how these attitudes form and change.

5. LIMITATIONS OF THE STUDY

While this study provides valuable insights into pre-service science teachers' attitudes toward experiments in science education, certain limitations should be acknowledged:

Sample Size: Only 82 pre-service teachers participated in the survey, which may not accurately reflect the opinions of all future science teachers in South Africa. A bigger sample size could show how broadly the results can be applied.

Self-Reported Data: Because the study used structured questionnaires, participants' answers were dependent on their own assessments of themselves, which might be skewed by social worth or bias.

Cross-Sectional Design: Because the data was gathered all at once, it was not possible to track how attitudes changed over time. A deeper understanding of changing views could be possible with longitudinal research.

Limited Scope: Without digging deeper into elements like instructional strategies, institutional support, or cultural influences that could impact attitudes toward experiments, the study mainly concentrated on gender differences and overall attitudes.

Use of Non-Parametric Tests: Non-parametric tests, which could have less statistical power than parametric tests, were employed because of the data's non-normal distribution.

Despite these limitations, the study provides a strong foundation for understanding pre-service teachers' attitudes and highlights areas for future research to expand on its findings.

6. AREAS OF FUTURE RESEARCH [for masters]

Influence of Classroom Resources and Infrastructure: The study suggests that understanding the influence of classroom resources, including laboratory equipment and materials, on pre-service teachers' attitudes towards experiments could offer valuable insights for enhancing science education.

Effect of Hands-on Experience:

- Further studies could focus on the correlation between hands-on experience with experiments during teacher training and the development of positive or negative attitudes towards experiments in the classroom.

- Examining the relationship between practical exposure and attitudes could inform curriculum design.

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APPENDICES/ANNEXURES

Appendix A: QUESTIONNAIRES

1. SECTION A: Demographic and Background

No	The Questions	Response
1.1	Gender	1=Male 2=Female
1.2	Age	1=18-20 2=21-23 3=24-26 4=27 or above
1.3	Major Subject	1=Biology 2=Chemistry 3=Physics 4=Mathematics
1.4	Science Courses taken	1=1-2 2=3-4 3=5-6 4=7 or more

2.

2. SECTION B: Independent variable ratings

The following are used in the table below: 1=Never(N), 2=Sometimes (S) 3=Often (O) 4=Always (A).					
No	Questions	Response			
2.1	How often have you used Real (hands-on) experiments at high school level?	N	S	O	A
2.2	How often do you use hands-on activities in science courses in the teacher education program?	N	S	O	A
2.3	How often have you used simulations experiments at high school level?	N	S	O	A
2.4	How often do you use simulations in science courses in the teacher education program?	N	S	O	A

3.

3. SECTION C: Attitudes towards Science Experiments

The following are used in the table below:

1=Strongly disagree (SD)

3=Neutral(N)

5=Strongly agree (SA)

2=Disagree (D)

4=Agree (A)

No	Questions	Response				
3.1	I prefer hands-on experiments over simulations.	SA	A	N	D	SD
3.2	I prefer simulations over hands-on experiments.	SA	A	N	D	SD
3.3	I enjoy conducting experiments in science lab courses.	SA	A	N	D	SD
3.4	I feel stressed when conducting experiments in science lab courses.	SA	A	N	D	SD
3.5	I feel insecure about my ability to conduct experiments in science lab courses.	SA	A	N	D	SD
3.6	I am confident that I can conduct experiments successfully in science lab courses.	SA	A	N	D	SD
3.7	I am confident that I can teach science experiments effectively in my future classrooms.	SA	A	N	D	SD
3.8	I think conducting experiments is an important part of learning science.	SA	A	N	D	SD
3.9	I think conducting experiments helps me understand scientific concepts better.	SA	A	N	D	SD
3.10	I think conducting experiments helps me develop scientific skills and attitudes.	SA	A	N	D	SD
3.11	I think conducting experiments makes science more interesting and relevant to life.	SA	A	N	D	SD
3.12	I intend to use experiments frequently in my future science teaching.	SA	A	N	D	SD
3.13	Please indicate your level of agreement with the statement: "Experiments are essential for effective science education."	SA	A	N	D	SD
3.14	Science education programs should consider gender-related attitudes when deciding whether to use real or simulated experiments.	SA	A	N	D	SD
3.15	I think gender-related differences matter in the attitudes of my peers regarding the use of experiments in science education.	SA	A	N	D	SD

3.16	I think the availability of resources (e.g., laboratory equipment) is important when choosing between real and simulated experiments.	SA	A	N	D	SD
3.17	I think my prior experience with real experiments influence my preference over simulations.	SA	A	N	D	SD
3.18	I think my prior experience with simulations experiments influence my preference over real experiments.	SA	A	N	D	SD
3.19	Gender-related attitudes or expectations can influence the choices between real and simulated experiments.	SA	A	N	D	SD

4.

Appendix B: ETHICAL CLEARANCE CERTIFICATE

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Ms SG Mukwevho

STUDENT NO:
11635289

PROJECT TITLE: **The attitudes of pre-service teachers towards the use of experiments in teaching and learning science.**

ETHICAL CLEARANCE NO: FHSSE/24/CSEM/22/0509

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr SJM Koheru	UNIVEN, Business Management	Supervisor
Ms SG Mukwevho	UNIVEN, Business Management	Investigator-Students

Type: **Masters Research**

Risk: **Minimal risk to humans, animals or environment (Category 2)**

Approval Period: **September 2024 – September 2025**

The Research Ethics Social Sciences Committee (RESSC) hereby approves your project as indicated above.

General Conditions

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following.

- The project leader (principal investigator) must report in the prescribed format to the REC:
 - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project.
 - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the REC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date; a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the REC retains the right to:
 - Request access to any information or data at any time during the course or after completion of the project.
 - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
 - withdraw or postpone approval if:
 - Any unethical principles or practices of the project are revealed or suspected.
 - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
 - The required annual report and reporting of adverse events was not done timely and accurately.
 - New institutional rules, national legislation or international conventions A if necessary

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: September 2024

Name of the RESSC Chairperson of the Committee: **Prof M. Mwale-Manjoro**

Signature: 



Appendix C:

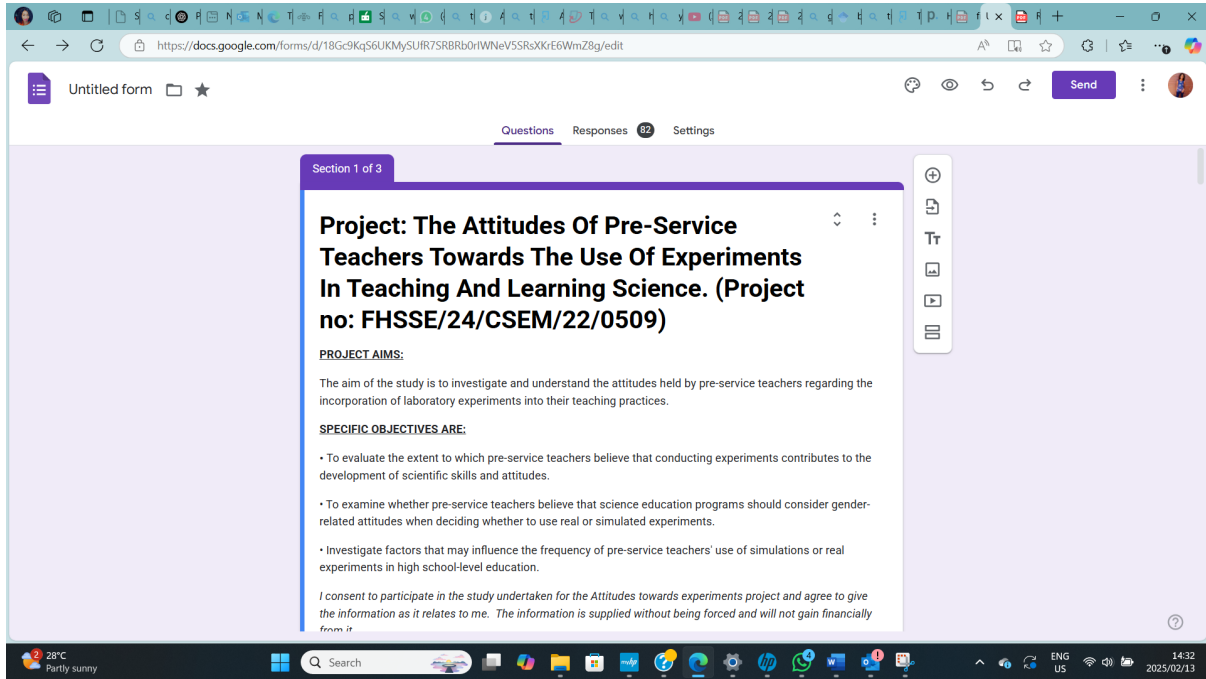
Table 4.1 Descriptives table

Descriptives

	Gender		Statistic	Std. Error
ConductingExperimentsHe IpsDevelopScientificSkillsA ndAttitudes	Male	Mean	3,92	,234
		95% Confidence Interval for Mean	Lower Bound Upper Bound	3,44 4,39
		5% Trimmed Mean	4,02	
		Median	4,50	
		Variance	1,964	
		Std. Deviation	1,402	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	-1,097	,393
		Kurtosis	-,138	,768
	Female	Mean	3,98	,223
		95% Confidence Interval for Mean	Lower Bound Upper Bound	3,53 4,43
		5% Trimmed Mean	4,09	
		Median	5,00	
		Variance	2,288	
		Std. Deviation	1,513	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	-1,170	,350
		Kurtosis	-,226	,688
AvailabilityWhileChoosingB etweenRealOrSimulations	Male	Mean	3,83	,220
		95% Confidence Interval for Mean	Lower Bound Upper Bound	3,39 4,28
		5% Trimmed Mean	3,93	
		Median	4,00	
		Variance	1,743	
		Std. Deviation	1,320	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	-,859	,393
		Kurtosis	-,369	,768
	Female	Mean	3,87	,223
		95% Confidence Interval for Mean	Lower Bound Upper Bound	3,42 4,32
		5% Trimmed Mean	3,97	
		Median	5,00	
		Variance	2,294	
		Std. Deviation	1,515	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	-1,013	,350
		Kurtosis	-,535	,688
GenderRelatedDifferences MattersInAttitudesRegardin gUseExp	Male	Mean	2,89	,217
		95% Confidence Interval for Mean	Lower Bound Upper Bound	2,45 3,33
		5% Trimmed Mean	2,88	
		Median	3,00	
		Variance	1,702	
		Std. Deviation	1,304	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	-,029	,393
		Kurtosis	-,808	,768
	Female	Mean	2,78	,204
		95% Confidence Interval for Mean	Lower Bound Upper Bound	2,37 3,19
		5% Trimmed Mean	2,76	
		Median	3,00	
		Variance	1,907	
		Std. Deviation	1,381	
		Minimum	1	
		Maximum	5	
		Range	4	
		Interquartile Range	2	
		Skewness	,251	,350
		Kurtosis	-1,003	,688

Appendix D: DATA COLLECTION TOOL

GOOGLE FORM LINK : [Untitled form - Google Forms](https://docs.google.com/forms/d/18Gc9KqS6UKMySUIR7SRBRb0hWNeV5SRs0XkE6WmZ8g/edit)



The screenshot shows a Google Form titled "Project: The Attitudes Of Pre-Service Teachers Towards The Use Of Experiments In Teaching And Learning Science. (Project no: FHSSE/24/CSEM/22/0509)". The form is currently in the "Questions" tab, showing "Section 1 of 3". The form content includes:

PROJECT AIMS:

The aim of the study is to investigate and understand the attitudes held by pre-service teachers regarding the incorporation of laboratory experiments into their teaching practices.

SPECIFIC OBJECTIVES ARE:

- To evaluate the extent to which pre-service teachers believe that conducting experiments contributes to the development of scientific skills and attitudes.
- To examine whether pre-service teachers believe that science education programs should consider gender-related attitudes when deciding whether to use real or simulated experiments.
- Investigate factors that may influence the frequency of pre-service teachers' use of simulations or real experiments in high school-level education.

I consent to participate in the study undertaken for the Attitudes towards experiments project and agree to give the information as it relates to me. The information is supplied without being forced and will not gain financially from it.

The form is displayed in a web browser window with the URL <https://docs.google.com/forms/d/18Gc9KqS6UKMySUIR7SRBRb0hWNeV5SRs0XkE6WmZ8g/edit>. The browser's taskbar at the bottom shows the date and time as 14:32 on 2025/02/13, and the weather as 28°C Partly sunny.



Appendix F: Turnitin Report



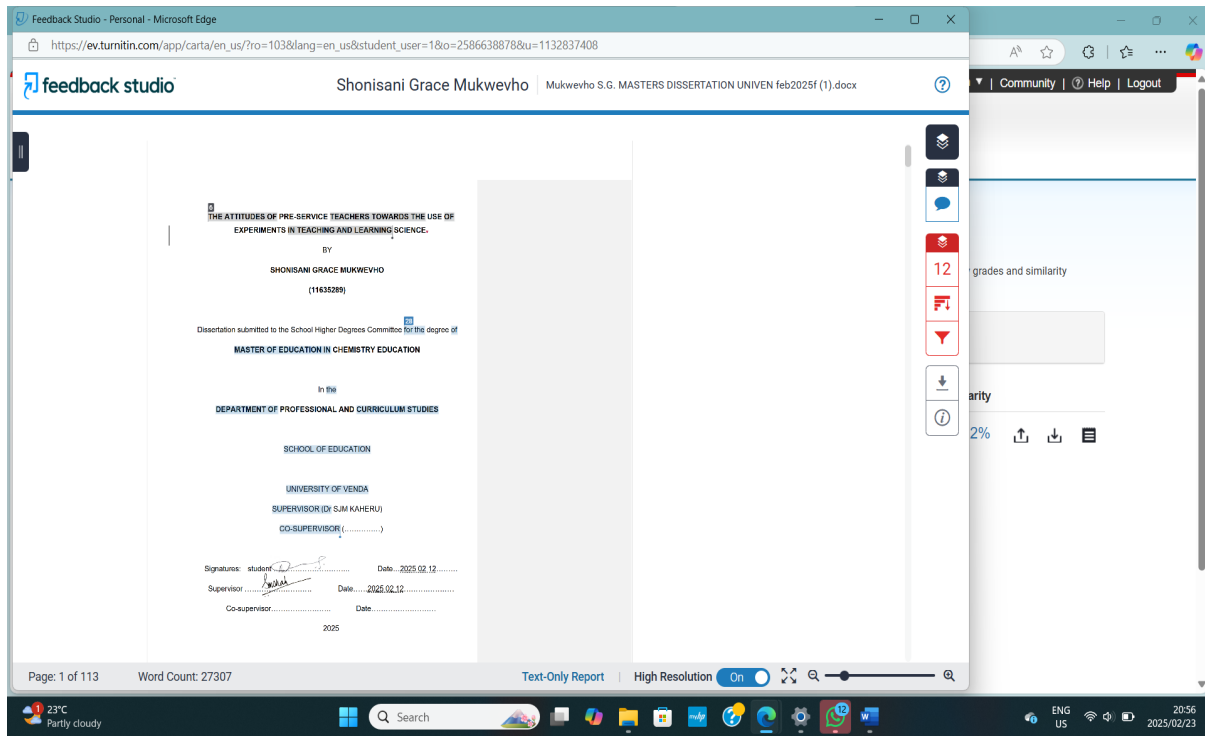
Digital Receipt

This receipt acknowledges that **Turnitin** received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author: Shonisani Grace Mukwevho
Assignment title: Final Submissions 2024
Submission title: Mukwevho S.G. MASTERS DISSERTATION UNIVEN feb2025f (1)....
File name: Mukwevho_S.G._MASTERS_DISSERTATION_UNIVEN_feb2025f_1...
File size: 2.91M
Page count: 113
Word count: 27,307
Character count: 169,800
Submission date: 23-Feb-2025 08:52PM (UTC+0200)
Submission ID: 2586638878





The screenshot displays the Turnitin Feedback Studio interface within a Microsoft Edge browser. The main window shows a document titled "THE ATTITUDES OF PRE-SERVICE TEACHERS TOWARDS THE USE OF EXPERIMENTS IN TEACHING AND LEARNING SCIENCE" by SHONISANI GRACE MUKWEVHO. The document is submitted for the degree of MASTER OF EDUCATION IN CHEMISTRY EDUCATION at the UNIVERSITY OF VENDA. The interface includes a sidebar with navigation tools, a central document view, and a right-hand panel with a list of feedback items. The bottom status bar indicates "Page: 1 of 113" and "Word Count: 27307". The Windows taskbar at the bottom shows the date as 2025/02/23 and the time as 20:56.

Feedback Studio - Personal - Microsoft Edge
https://ev.turnitin.com/app/carta/en_us/?ro=103&lang=en_us&student_user=18&o=2586638878&u=1132837408

feedback studio Shonisani Grace Mukwevho Mukwevho S.G. MASTERS DISSERTATION UNIVEN feb2025f (1).docx

THE ATTITUDES OF PRE-SERVICE TEACHERS TOWARDS THE USE OF EXPERIMENTS IN TEACHING AND LEARNING SCIENCE.
BY
SHONISANI GRACE MUKWEVHO
(11635289)
Dissertation submitted to the School Higher Degrees Committee for the degree of
MASTER OF EDUCATION IN CHEMISTRY EDUCATION
In the
DEPARTMENT OF PROFESSIONAL AND CURRICULUM STUDIES
SCHOOL OF EDUCATION
UNIVERSITY OF VENDA
SUPERVISOR (Dr. S.M. KAHERU)
CO-SUPERVISOR (.....)
Signatures: student: Date: 2025.02.12
Supervisor: Date: 2025.02.12
Co-supervisor: Date:
2025

Page: 1 of 113 Word Count: 27307 Text-Only Report High Resolution On

23°C Partly cloudy Search 20:56 2025/02/23

Appendix G: Editor Letter

Editing and Proofreading Report

February 2025

This letter serves to confirm that I, Trenance Khoza, have edited and proofread the Dissertation titled: **The Attitudes of Pre-service Teachers Towards the Use of Experiments in Teaching and Learning Science, by Shonisani Grace Mukwevho**
Student Number: 11635289.

I carefully read through the proposal, focusing on proofreading and editorial issues. The recommended suggestions are clearly highlighted in red ink and can either be accepted or rejected using the Microsoft Word track changes system.

Yours sincerely



Trenance Khoza (PhD Eng)

+263 772389974 / 263 774779968

E-mail: ndlovutrenance2012@gmail.com or khozat@staff.msu.ac.zw