

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF SCIENCE EDUCATION

**The use of context-based teaching approach to improve students' Academic
Performance in the particulate nature of Matter**



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**THE USE OF CONTEXT-BASED TEACHING APPROACH TO IMPROVE
STUDENTS' ACADEMIC PERFORMANCE IN THE PARTICULATE
NATURE OF MATTER**

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

AUGUST, 2024

DECLARATION

Student's Declaration

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

Signature:

Date:



Supervisor's Declaration

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

Name: Dr. Stephen Twumasi Annan

Signature:

Date:

DEDICATION

This work is dedicated to myself, in recognition of the perseverance and dedication that have sustained me throughout this academic journey, and to a remarkable individual, Edith Sagoe, whose unwavering support, encouragement, and belief in my potential have been instrumental to my growth and success. Her presence has been a constant source of strength, and for that, I am deeply grateful.



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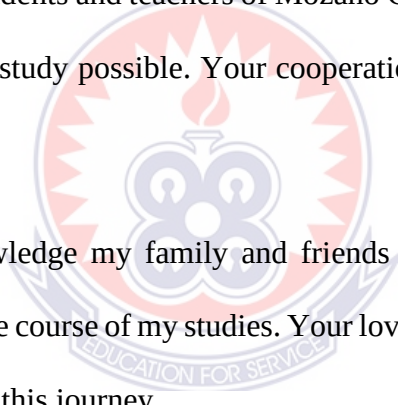


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Figure 1: Conceptual Framework of the Study

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
CBL	:	Context-Based Learning
CFA	:	Confirmatory Factor Analysis
CPD	:	Continuing Professional Development
EFA	:	Exploratory Factor Analysis
EL	:	Experiential Learning
ICT	:	Information and Communication Technology
M	:	Mean
N	:	Sample Size
PCK	:	Pedagogical Content Knowledge
PLS SEM	:	Partial Least Squares Structural Equation Modelling
SD	:	Standard Deviation
SEM	:	Standard Error of the Mean
SPSS	:	Statistical Package for the Social Sciences
SR	:	Scientific Reasoning
STEM	:	Science, Technology, Engineering, and Mathematics
STS	:	Science, Technology, and Society
t-Test	:	A statistical test used to compare the means of two groups
TPACK	:	Technological Pedagogical Content Knowledge

ABSTRACT

This study explored the use of a context-based teaching approach to improve senior high school students' academic performance in the particulate nature of matter. The research was conducted at Mozano College of Music Senior High School in Ghana, employing an action research design with a mixed-methods approach. Thirty-seven (37) Form Two General Arts students were purposively selected for the intervention. Data were gathered using achievement tests and semi-structured interviews, and analysed through descriptive and inferential statistics. The results indicated a marked improvement in students' academic performance, with mean test scores increasing from 7.38 (pre-test) to 22.78 (post-test), showing a statistically significant difference ($p < 0.05$). Both male and female students benefited equally from the intervention. Additionally, students reported enhanced understanding, critical thinking, motivation, and an appreciation of real-life applications of the concepts learned. In conclusion, the context-based teaching approach significantly improved students' understanding and academic performance in the particulate nature of matter. It also positively influenced their learning attitudes and engagement. Based on these findings, it is recommended that science teachers at Mozano College of Music Senior High School incorporate context-based teaching strategies to enhance science instruction and promote meaningful learning.



CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter contains the background to the study, the statement of the problem, the purpose of the study, the research objectives, research questions, research hypotheses, significance of the study, limitations of the study, delimitations of the study and organisation of the study.

1.1 Background to the Study

Chemistry has been regarded as a difficult subject for students by teachers, researchers and educators (Sibomana et al., 2021). The reasons for students' difficulties may be related to the abstract nature of many chemistry concepts, students' limited visualisation abilities, the language of chemistry and particularly, the teaching methods employed (Kausar et al., 2024).

Research studies on chemistry conceptual knowledge indicate that most students do not have a sound understanding of some fundamental concepts that form the basis of the chemistry discipline such as conservation of matter and chemical equations (Krajcik, 2012), chemical equilibrium (Koretsky, 2020) particulate nature of matter (Tan et al., 2022), chemical bonding (Hunter et al., 2022) and electrochemistry (Ali et al., 2022). However, the particulate nature of matter stands out to be one of the most difficult concepts for students to understand (Banda et al., 2011; Ozmen & Kenan, 2007). Yet, the particulate nature of matter provides a basis for understanding the invisible microscopic events underlying natural phenomena (Klutse, 2021). As such, there is a consensus among chemistry educators that the particulate nature of matter is fundamental to understanding other chemical concepts (Smith, 2022; Sole et al., 2023).

For example, students with poor knowledge about the particulate nature of matter are likely to have difficulties understanding the kinetic theory of matter, chemical kinetics, and phase changes (Smith et al., 2018).

Over the past few decades, science education has been making continuous efforts to promote meaningful learning and higher-order thinking skills globally as well as to slowly scrape traditional teaching methods (Ramesh et al., 2020). Nzewi (2011), proposed the need for a search for better instructional methods for the attainment of improved learning outcomes and notable among such innovative approaches is the Context-Based Teaching Strategy (CBTA). Context-based teaching method helps the teachers relate the concepts being taught to the students to real-world situations leading to students' motivation to learn the concepts by connecting them to their day-to-day experiences (Taconis et al., 2016; Srinivasa et al., 2022; Nyirantambineza & Minani, 2022). Context-based teaching approaches try to cope with the highly theoretical nature of the chemistry subject by introducing everyday contexts. In the teaching context, the personal, peer, environmental and experiences of the learners must be included. During the establishment of links and contexts, students' experiments involving materials that are commonly available are utilised (Gilbert, 2006). Selection of appropriate contexts must be by students' everyday lives and teaching through these contexts would help maintain the students' attention in the lessons (Unal, 2008). In addition, making the content structure more relevant to students' everyday lives was seen as a way to raise interest levels and foster learning. Learning in context is one of the instruments that motivate and encourage students to learn the concepts meaningfully and develop positive attitudes towards them (Bennett et al., 2007).

Some studies have been carried out to find out the influence of gender on student achievement in science generally and on student achievement in chemistry in particular

(Anidu, 2007), Unfortunately, the findings seem to be inconclusive. For example, Oladejo et al. (2023) revealed that there was no significant difference in the academic performance of male and female students in chemistry while Egbo (2005) observed a significant difference in academic performance due to gender. Therefore, there is a need to determine, how the effects of CBTA would affect student academic performance in the particulate nature of matter concerning gender.

Several studies have shown that context-based teaching improves students' academic performance and interest in science (Danis et al., 2017; Tariq & Saeed, 2021; Yilmaz et al., 2022; Tatal, 2023). However, there is limited literature on the effects of CBT on senior high school students' performance in the particulate nature of matter in the Ghanaian context. Hence, it is against this background that the study was conducted.

1.2 Statement of the Problem

The concept of the Particulate Nature of Matter (PNM) is fundamental to understanding a wide range of chemical phenomena, including phase changes, chemical bonding, and reactions. Despite its centrality to chemistry instruction, students at the Senior High School level in Ghana continue to demonstrate significant conceptual difficulties and persistent misconceptions related to this topic (Banda et al., 2011; Njoku, 2009). These conceptual challenges often manifest in poor academic performance, a lack of motivation, and the inability to apply particulate concepts in explaining real-world chemical phenomena.

Preliminary classroom observations conducted by the researcher at Mozano College of Music Senior High School further substantiates these concerns. Following a reassignment in teaching responsibilities, the researcher assumed instructional duties for a Form 2 class (2 Arts 1), where the PNM had been previously covered in Form 1.

Through informal diagnostic assessment, including oral questioning and review of students' notebooks, exercises, and test scripts, widespread misconceptions and poor understanding were observed. These observations were corroborated by the former chemistry teacher, who confirmed the students' low achievement levels on PNM-related assessments. The data suggested that students could not meaningfully describe particle behaviour, especially during changes of state, nor relate such behaviour to everyday contexts indicating gaps in conceptual understanding.

The persistence of these learning difficulties has been attributed in part to the predominance of traditional pedagogical approaches, which rely heavily on teacher-centred, lecture-based instruction (Ayas et al., 2010; Taber, 2009). Such methods often neglect the use of real-world contexts, thereby limiting students' ability to visualise and internalise sub-microscopic particle interactions. Literature supports that without appropriate instructional scaffolding, students are unlikely to move beyond surface-level memorisation to achieve conceptual change (Johnstone, 2011; Liu & Lesniak, 2005).

Although context-based teaching has been explored in science education (Rayner, 2005; Gutwill-Wise, 2001; Achor, 2024), few empirical studies have specifically examined its impact on students' performance and conceptual understanding of the PNM in the Ghanaian SHS context. Furthermore, the influence of gender on learning outcomes within such instructional frameworks remains underexplored. Additionally, there is limited research addressing students' perceptions of the context-based teaching approach as a tool for enhancing learning in abstract chemistry topics.

This study, therefore, addresses a clearly identified research gap by investigating the use of a Context-Based Teaching Approach (CBTA) to improve students' academic

performance in the Particulate Nature of Matter. Specifically, the study aims to evaluate the effect of CBTA on conceptual understanding, examine gender-related differences in learning outcomes, and explore students' perceptions of the instructional approach.

1.3 Purpose of the Study

The purpose of the study was to use of context-based teaching approach to improve students' academic performance in the particulate nature of matter.

1.4 Research Objectives

The objectives of the study were to:

1. Examine students' existing conceptions about the particulate nature of matter.
2. Assess students' academic performance before and after the use of context-based approach in teaching and learning of the particulate nature of matter.
3. Assess the academic performance of male and female students before and after the implementation of context-based teaching approach in teaching and learning of the particulate nature of matter.
4. Explore students' perceptions of context-based teaching in instruction and learning of the particulate nature of matter.

1.5 Research Questions

The following research questions guided the focus of the study:

1. What are students' existing conceptions about the particulate nature of matter?
2. What is the academic performance of students before and after the use of context-based approach in teaching and learning the particulate nature of matter?

3. What is the academic performance of male and female students before and after the implementation of a context-based teaching approach in instruction of the particulate nature of matter?
4. What are students' perceptions of context-based approach in teaching and learning of the particulate nature of matter?

1.6 Research Hypotheses

The following research hypotheses were tested for statistical significance:

H₀₁: There is no statistically significant difference in the academic performance of students before and after the use of context-based approach in teaching and learning of the particulate nature of matter.

H₀₂: There is no statistically significant difference in the academic performance of male and female students before and after the implementation of context-based teaching approach in instruction of the particulate nature of matter.

1.7 Significance of the study

The study was significant for several reasons:

The study demonstrates that the use of a Context-Based Teaching Approach (CBTA) led to improved academic performance in the Particulate Nature of Matter (PNM). This result confirms the value of instructional strategies that link scientific content to students' everyday experiences, thereby enhancing understanding of abstract concepts.

Secondly, the study offers practical implications for chemistry teachers at Mozano College of Music SHS and beyond. It introduces an effective pedagogical strategy CBTA for delivering abstract and challenging topics in science. By anchoring lessons in real-life contexts familiar to students, the approach not only promotes deeper conceptual understanding but also increases student engagement and motivation.

Furthermore, this study provides a foundation for future educational research by serving as a reference for other researchers who are interested in exploring the use of context-based instructional methods in similar educational environments. It contributes to the existing literature on effective science teaching methods in Ghana and encourages the adoption of learner-centred and constructivist-oriented strategies.

1.8 Limitations of the Study

The participants' unique characteristics, such as varying educational backgrounds and language proficiencies, may have influenced the results, reducing their applicability to diverse educational settings. Additionally, time constraints hindered a more comprehensive data collection process, limiting the exploration of all relevant variables and factors affecting student performance. The reliance on self-reported data from students and teachers introduced potential biases, further impacting the reliability and validity of the findings. These limitations suggest the need for caution in generalizing the results.

1.9 Delimitations of the Study

Although there are many concepts in science, the study focused on the particulate nature of matter. The study only included students at the secondary level of education. Tertiary and basic-level students were not included in the study. The study focused on only Mozano College of Music Senior High school students.

1.10 Organisation of the Study

Chapter one introduced the study by providing a comprehensive background and detailing the problem statement. It outlined the purpose of the study, defined the research objectives, and presented the research questions and hypotheses. Additionally,

this chapter discussed the significance of the study, its limitations, and delimitations, and concluded with the organization of the study.

Chapter two, the literature review, explored the theoretical and conceptual frameworks relevant to the study. It covered key concepts such as perception, examined gender differences in education, and provided an overview of the Ghanaian Education System. This chapter also discussed context-based teaching strategies and their application in science education, along with the associated challenges and benefits.

Chapter three focused on the research methodology, detailing the research design, population, and sample. It also explained the data collection instruments and techniques for data analysis, and addressed ethical considerations pertinent to the study.

In chapter four, data presentation and analysis, the study presented the collected data and provided a detailed discussion of the findings. This analysis was linked to the research objectives and questions, offering a thorough examination of the results.

Finally, chapter five summarized the study's conclusions in the discussion, conclusion, and recommendations section. It provided recommendations for educators and policymakers based on the findings and suggested potential areas for further research.

1.11 Operational Definition of Terms

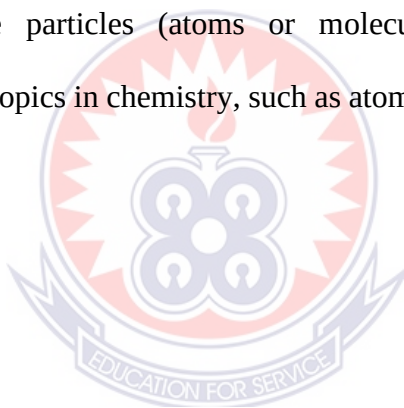
Academic Performance: Refers to the ability of students to achieve high grades and standardized test scores in school subjects, particularly those that are part of the core academic curriculum (Louis, 2012).

Context: Defined as a coherent collection of practical situations that require better understanding and/or decisions to be made at a personal or societal level (Kortland, 2005).

Perception: A constructive process by which individuals go beyond the stimuli presented to them and attempt to construct a meaningful situation (Sudrajat et al., 2018).

Context-Based Teaching Approach (CBT): A pedagogical strategy that integrates real-life contexts into the learning process, helping students to see the relevance of scientific concepts by relating them to everyday experiences (Bennett & Lubben, 2006).

Particulate Nature of Matter: A scientific concept that describes matter as being composed of discrete particles (atoms or molecules) and is fundamental to understanding various topics in chemistry, such as atomic structure, chemical bonding, and chemical reactions.



CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides a comprehensive review of the existing literature related to the challenges students face in understanding and applying the particulate nature of matter. It begins with an exploration of the theoretical framework underpinning this study, grounded in constructivist learning theory, which emphasizes active, individualized learning and the importance of social interactions. The chapter then delves into the conceptual framework, illustrating how the study was structured across input, process, and output stages. It further explores the concept and measurement of academic performance, highlighting various definitions and assessment methods. The chapter also examines the role of perception in education, discussing its impact on student learning and the biases that can affect both educators and learners. A significant portion of the chapter is dedicated to the context-based teaching approach, analysing its principles, implementation, and effectiveness in science education, particularly within the Ghanaian context. Additionally, it reviews gender differences in science education, considering how context-based teaching can potentially address disparities. Finally, an empirical review of related studies is presented, offering insights into previous research findings on context-based teaching and its impact on students' academic performance, with a focus on the particulate nature of matter.

2.1 Theoretical Framework

The theoretical framework that underpinned this study was the constructivist learning theory (Vygotsky, 1978). Constructivism emphasises that learning is an active and individualised process where students construct their understanding of knowledge

through interaction with their environment, including the learning materials and their peers.

In the context of this study, the constructivist learning theory can be applied to understand students' difficulties in particulate nature of matter. It suggests that students may have preconceived notions or misconceptions about particulate nature of matter, which can influence their learning outcomes (Driver et al., 2007). By identifying these difficulties, the study can focus on addressing and reshaping students' understanding of particulate nature of matter through teaching interventions.

The context-based teaching approach, which aims to provide meaningful and real-world contexts for learning, aligns with the constructivist learning theory. It encourages students to actively engage with the subject matter and make connections between the concepts and their practical applications. This approach supports the idea that learning is more effective when students can relate the knowledge to their own experiences and see its relevance (Falk & Dierking, 2000).

Additionally, the constructivist learning theory acknowledges the social aspect of learning. It recognizes that students can benefit from interactions with their peers, such as through collaborative problem-solving or discussions. This aspect can be leveraged in the study to facilitate peer-to-peer interactions during the teaching interventions, allowing students to learn from and support each other in overcoming difficulties (Gredler, 2010).

By applying the constructivist learning theory as a theoretical framework, the study can gain insights into how students construct their understanding of particulate nature of matter, the impact of context-based teaching on their learning outcomes, and the potential role of social interactions in improving their performance.

2.2 Conceptual Framework of the Study

Figure 1 shows the conceptual framework of the study. It involves three stages; input stage, process stage and output stage.

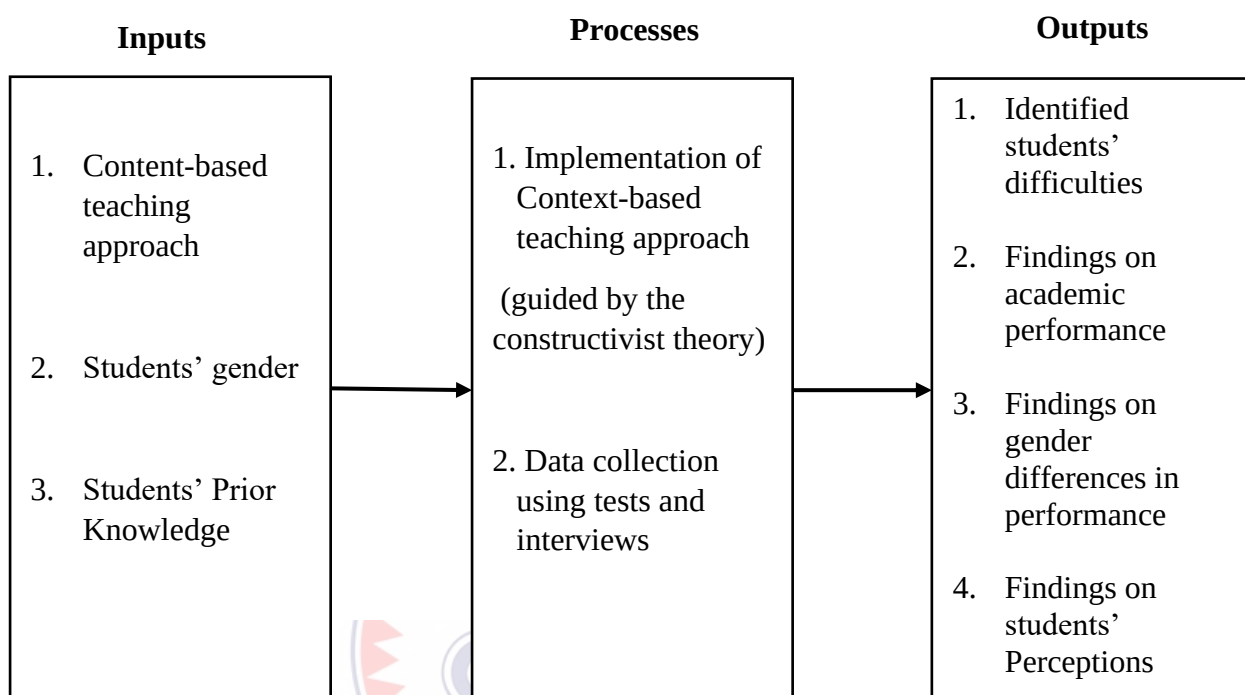


Figure 1: Conceptual Framework of the Study

2.2.1 Input Stage

At this initial stage, the focus was on gathering relevant information to inform the content-based teaching approach. This included considering factors such as students' gender and their prior knowledge. Gender was taken into account as it can influence learning preferences, interests, and even performance outcomes. Understanding these differences allowed for the customisation of teaching methods to better suit the diverse needs of students. Assessing students' prior knowledge provided insights into their existing understanding of the subject matter. This previous knowledge served as a foundation upon which new concepts could be built, ensuring that instruction was appropriately targeted and effective.

2.2.2 Processes Stage

In this stage, the emphasis shifted towards the actual implementation of the content-based teaching approach which was guided by the constructivist theory. This involved designing and executing instructional strategies that integrated relevant contexts into the learning experience. Context-based teaching aims to make learning more meaningful and engaging by connecting concepts to real-life situations or experiences. By embedding content within familiar contexts, students were better able to comprehend and retain information. Additionally, data collection methods such as tests and questionnaires were utilised to gather information about students' learning progress and comprehension. These assessments provided valuable feedback on the effectiveness of the teaching approach and identified areas where further support or adjustments might be needed.

2.2.3 Output Stage

Finally, in the output stage, various outcomes of the teaching approach were identified and analysed. This included identifying specific difficulties or challenges that students encountered during the learning process. Understanding these difficulties allowed the Researcher to provide targeted support and interventions to address individual learning needs. Academic performance analysis involves assessing student achievement and progress over time. By comparing performance data before and after the implementation of the content-based teaching approach, the Researcher could evaluate its impact on student learning outcomes. Gender differences in performance were also examined to identify any disparities or patterns that may exist. This analysis helped ensure that teaching strategies were equitable and inclusive, addressing the diverse needs of all students. Finally, gathering students' views and perspectives on the learning experience provided valuable insights into their engagement, satisfaction and overall

perceptions of the content-based teaching approach. This feedback informed future instructional decisions and improvements to the teaching methodology.

2.3 Concept of Academic Performance

The Academic Performance Index (2013) revealed that academic performance is how students deal with their studies and the responsibilities given to them by their teachers. Louis (2012) indicated that academic performance is the ability of students to obtain high grades and standardised test scores in school subjects, especially subjects that are part of the core academic curriculum. Lavin (2001) gives an objective definition of the term academic performance as some method of stating or expressing a student's academic rank, generally, this is a grade for a particular subject area or an average for all subjects expressed on a 0 to 100 or another quantitative scale. According to Mankoe (2002), performance refers to the extent to which a worker or student contributes to achieving the goals of his or her institution. Popoola (2010) defined academic performance as an expression used to present a student's scholastic standing and which is a function of various factors such as the method of teaching, teachers' qualifications, child's home background, school environment, attitude and interest among others.

According to Nicholas (2004), the most current information on improving academic performance shows that there are three conditional influences linked to levels of academic performance among school pupils. These influences according to the information include high-quality parenting (the degree to which a young star is provided with an enriched, warm and responsive learning and home environment), high-quality child-care environments (stimulating activity and nurturing as reflected in high-quality parenting) and high-quality first-grade classrooms (with a focus on literacy instruction, evaluative feedback, instructional conversation, and encouraging child responsibilities).

2.4 Measurement of Academic Performance

Kirschner and Karpinski (2013) asserted that the evaluation or determination of academic performance is concerned more fundamentally with deciding on the value or executed worthwhile of a learning process as well as the effectiveness with which it is been. Kirschner and Karpinski mentioned that, usually two basic areas are evaluated. First is the academic performance of the students about the philosophy and objectives of the education he/she is receiving. The second is how well the curriculum goals are been realised for the level of education.

Yusuf (2012) described evaluation as the collection and use of information as a basis for rational decision-making on the subject or topics which needs to be improved, or modified. It is a quality control exercise to ensure that resources are used maximally. Yusuf has identified the following instruments to be used in evaluating the teaching-learning process which are tests, observation, projects, questionnaires, interviews, checklists and sociometric techniques or sociometry.

According to Lavin (2001), the academic performance of students can also be measured in the following ways:

Give a standardised achievement test

A standardised test has to be given by someone who meets the qualifications required in the testing manual. Usually, that is a person who has coursework in administering that type of assessment. Standardised achievement tests compare the students being tested with the average student of the same age in a sample of students across the country. The advantage of these types of standardised tests is that they are well-researched and usually have good validity and reliability. The disadvantage is that they

do not tell where that child is at given what they have been taught in their classroom in their school district.

Analyse test findings

Each country chooses its standardised test to measure achievement and each defines its level of proficiency on that test. However, a student could have guessed well on the test or they could have had a bad day on the day of the test. This is one good way of telling what a student has learned but it should be considered along with other sources of information.

Use informal questionnaires to measure academic success

Teacher surveys based on what has been taught in the classroom can be a good indicator of academic performance. These are sometimes included in textbooks or they can easily be made up. They are a good tool to use to see what has been learned, what has been retained over time, and what has not been mastered and needs to be re-taught.

Examine grade reports

Grades are one tool to use to measure academic performance. They are a great indicator of academic success and short-term learning. However, grades do not necessarily measure long-term learning or mastery. For example, some students may do well on tests because they can memorise information and relate it at test time. However, it may be questionable if it was actual learning if they forget it right after the test and cannot demonstrate that knowledge at a later time. Grades are partially based on short-term knowledge that comes from weekly tests and homework, and only part of the grades is more long-term knowledge.

Critique of Assessment Practices and Rationale for Approach Used in This Study

Grades are often used as the primary measure of academic performance in many educational systems, including Ghana. While they provide a useful snapshot of student achievement at a particular point in time, grades may not always offer an accurate reflection of deep or long-term learning. In most Ghanaian Senior High Schools, assessment is heavily focused on standardised tests, class exercises, and end-of-term examinations. These tools tend to measure students' ability to recall and reproduce content rather than assess their understanding or ability to apply knowledge in real-life situations.

The emphasis on short-term memorisation in preparing for examinations has resulted in teaching strategies that prioritise test preparation over conceptual understanding. Students are often encouraged to memorise definitions, equations, and procedures with little opportunity to explore underlying principles or apply their knowledge to unfamiliar contexts. As a result, many learners are able to perform well in class tests but struggle to retain or transfer that knowledge to other areas or later academic work. This practice raises concerns about the validity of grades as indicators of actual learning, particularly in science subjects where abstract concepts require deep engagement and cognitive processing.

In the context of science education, and specifically in the teaching of topics such as the particulate nature of matter, this over-reliance on grades can be particularly problematic. A student may earn a high score by recalling that “particles move faster when heated” without truly understanding what this implies at the molecular level. Consequently, there is a risk that grades reflect rote learning rather than genuine comprehension or the ability to apply scientific reasoning to real-life phenomena.

Recognising these limitations, the present study adopted a more holistic approach to assessing academic performance and understanding. Rather than relying solely on final grades or conventional classroom tests, a pre-test and post-test model was employed to measure students' conceptual progress over the course of the intervention. The tests were designed to assess not only factual recall but also the ability to explain observable events using particle-level reasoning. In addition, students' perceptions of the context-based teaching approach were explored through interviews, providing qualitative insights into how the instructional method influenced their engagement and understanding.

This approach offered a more balanced view of student learning, combining measurable outcomes with personal reflections. By including both performance data and learner perspectives, the study aimed to go beyond surface-level achievement and gain a deeper understanding of how students make sense of scientific concepts. In doing so, it responds to the current shortcomings in assessment practices in Ghana and highlights the need for assessment models that value meaningful, long-term learning over short-term performance.

2.5 Concept of Perception

Vedi and Dulloo (2021) defined perception as a process that starts from the use of the five senses in receiving a stimulus, then it is organised and interpreted so that it has an understanding of what is sensed. Sudrajat et al. (2018) stated that perception is a constructive process by which we go beyond the stimuli that are presented to us and attempt to construct a meaningful situation, whereas Wade and Swanston (2013) stated that perception refers to the way something sounds, feels, tastes, or smells. In other words, perception can be defined as whatever is experienced by a person.

Understanding Positive and Negative Perception in the Learning Context

Perception is fundamentally the process by which an individual interprets and assigns meaning to sensory stimuli received from their environment. It involves not only the reception of external input through the senses, but also the internal cognitive and emotional processes that shape how that information is understood. In the context of learning, perception plays a key role in determining how students engage with, interpret, and respond to instructional content and teaching methods.

A perception can be described as positive when an individual interprets an experience, object, or method in a way that aligns with their expectations, beliefs, or prior knowledge. Positive perceptions are often associated with acceptance, motivation, confidence, and increased engagement. For example, when a student finds a lesson relevant and understandable, they are likely to perceive it positively and engage more actively in learning. This favourable interpretation leads to constructive responses such as asking questions, contributing to discussions, and applying knowledge effectively.

Conversely, a negative perception arises when an individual interprets a stimulus in a way that conflicts with their prior beliefs, causes discomfort, or fails to meet their expectations. In such cases, the learner may disengage, show resistance, or struggle to process and retain new information. A student who finds a teaching method confusing or irrelevant may form a negative perception of the learning experience, which could influence their motivation and academic performance.

Therefore, both positive and negative perceptions are shaped not merely by the object or method being perceived, but by the person's interpretation of it. The perception does not reside in the object itself, but in the way the person makes sense of it. As such, two individuals exposed to the same teaching strategy may perceive it differently based on their prior experiences, interest levels, or learning preferences.

Arifin et al. (2017) describe perception as a four-stage process. The first stage involves the reception of a stimulus through the senses (e.g., hearing a teacher's explanation or seeing a demonstration). The second stage is physiological, where the stimulus is transmitted through the sensory nerves to the brain. The third stage is psychological, where the individual becomes aware of the stimulus and begins to interpret it. The final stage is the resulting response or behaviour, which reflects the individual's interpretation whether it is engagement, indifference, or resistance.

Perception is influenced by a combination of internal and external factors. Internal factors include one's emotions, attitudes, motivations, expectations, and physical state. External factors involve the environment, previous experiences, familiarity with the content, clarity of instruction, and social influences. Davis (2014) adds that perceived usefulness and perceived ease of use also affect how a person interprets a learning experience or system. If students believe that a teaching method helps them understand better (usefulness) and is easy to follow (ease of use), they are more likely to form a positive perception of it.

In this study, perception is viewed as the students' interpretation and appraisal of the context-based teaching approach used in learning the particulate nature of matter. Their responses, whether positive or negative, are shaped by how they made sense of the teaching strategy, based on their individual expectations, experiences, and interaction with the content. Understanding these perceptions provides valuable insight into the students' learning experiences and helps determine whether the teaching approach resonated with their needs.

2.5.1 The Process of Perception

The process of perception begins with the detection of stimuli through the sensory organs, such as the eyes, ears, nose, tongue, and skin. These sensory receptors convert physical stimuli into neural signals, which are then transmitted to the brain for processing (Bruce et al., 2014). This initial stage of perception, known as sensation, involves the raw detection of stimuli without any interpretation or meaning attached to it. Sensation is the foundation upon which perception is built, providing the brain with the necessary information to form a coherent understanding of the environment.

Once the sensory information is received, the brain organizes it into patterns and categories, a process known as perceptual organization. This stage involves several key processes, including grouping, pattern recognition, and figure-ground differentiation (Palmer, 2012). Grouping refers to the tendency to organize stimuli into coherent groups based on factors such as similarity, proximity, and continuity. Pattern recognition involves identifying familiar patterns within the sensory input, allowing us to recognize objects, faces, and other elements of our environment. Figure-ground differentiation is the ability to distinguish an object (the figure) from its surrounding background (the ground), a crucial aspect of visual perception.

The final stage of perception is interpretation, where the organized sensory information is assigned meaning based on past experiences, knowledge, and expectations. This stage involves higher-order cognitive processes, such as memory, attention, and reasoning, which influence how individuals interpret and respond to stimuli (Eysenck & Keane, 2015). The interpretation of sensory information is not always accurate, and it can be influenced by various biases and heuristics that shape our perception of reality.

2.5.3 Perception in Education

Perception plays a critical role in the educational context, influencing how students interpret and engage with learning materials, teachers' instructions, and classroom interactions. Students' perceptions of their abilities, the relevance of the content, and the learning environment can significantly impact their motivation, engagement, and academic performance (Schunk & Zimmerman, 2012).

Perceptions of self-ability and competence

Students' perceptions of their own abilities, often referred to as self-efficacy, are crucial determinants of their academic success. Self-efficacy refers to an individual's belief in their capacity to perform specific tasks or achieve certain goals (Bandura, 2012). Students with high self-efficacy are more likely to take on challenging tasks, persist in the face of difficulties, and ultimately achieve higher levels of academic performance. Conversely, students with low self-efficacy may avoid challenging tasks, give up easily, and experience lower academic outcomes.

Self-efficacy is shaped by various factors, including past experiences, feedback from teachers and peers, and comparisons with others (Schunk & Pajares, 2010). Teachers can influence students' self-efficacy by providing constructive feedback, setting achievable goals, and creating a supportive learning environment that encourages risk-taking and experimentation.

Perceptions of the learning environment

The way students perceive the learning environment, including the classroom atmosphere, teacher behaviour, and peer interactions, can have a profound impact on their motivation and engagement. A positive perception of the learning environment, characterized by a sense of belonging, respect, and support, can enhance students'

motivation to learn and participate in classroom activities (Eccles & Roeser, 2011). On the other hand, a negative perception of the learning environment, marked by feelings of alienation, discrimination, or lack of support, can lead to disengagement, absenteeism, and lower academic achievement.

Teachers' perceptions of students also play a critical role in shaping the learning experience. Teachers who hold high expectations for their students are more likely to engage them in challenging and meaningful learning activities, leading to better academic outcomes. Conversely, low expectations can result in self-fulfilling prophecies, where students perform poorly because they internalize the negative perceptions of their teachers (Rosenthal & Jacobson, 2008).

Perceptions of content relevance

Students' perceptions of the relevance of the content they are learning can significantly influence their motivation and engagement. When students perceive the content as relevant to their lives, interests, or future goals, they are more likely to be motivated to learn and retain the information (Ryan & Deci, 2020). Context-based teaching approaches, which connect academic content to real-world situations, can enhance students' perceptions of relevance and make learning more meaningful (Bennett & Lubben, 2013).

Conversely, when students perceive the content as irrelevant or disconnected from their experiences, they may become disengaged and less motivated to learn. Teachers can enhance the perceived relevance of content by relating it to students' interests, providing real-world examples, and demonstrating the practical applications of the knowledge being taught.

2.5.4 Perceptual Biases and Errors

While perception is a critical cognitive process that enables individuals to make sense of their environment, it is not immune to biases and errors. Perceptual biases refer to systematic deviations in perception that result from the influence of cognitive, emotional, or social factors (Tversky & Kahneman, 2014). These biases can lead to distortions in how individuals interpret sensory information, potentially affecting their judgments and decisions.

Confirmation bias

Confirmation bias is the tendency to search for, interpret, and remember information in a way that confirms one's preexisting beliefs or expectations. This bias can lead to selective perception, where individuals pay attention only to information that supports their views while ignoring or discounting contradictory evidence (Nickerson, 2018). In an educational context, confirmation bias can affect how students interpret feedback, evaluate evidence, and engage in critical thinking.

Halo effect

The halo effect is a cognitive bias in which an individual's overall impression of a person, object, or situation influences their perception of specific traits or characteristics. For example, if a student is perceived as diligent and hardworking, a teacher may be more likely to overlook mistakes or give them the benefit of the doubt in ambiguous situations (Thorndike, 2012). The halo effect can lead to biased evaluations and unfair treatment, affecting students' academic outcomes.

Stereotyping

Stereotyping is the tendency to categorize individuals based on generalized beliefs or assumptions about a particular group. Stereotypes can influence perception by shaping expectations and interpretations of behaviour. For instance, teachers may unconsciously hold stereotypes about students based on their gender, ethnicity, or socioeconomic status, which can affect how they perceive and interact with those students (Steele, 2010). Stereotyping can lead to biased judgments, unequal opportunities, and perpetuation of social inequalities in the classroom.

Perceptual set

Perceptual set refers to the predisposition to perceive stimuli in a particular way based on prior experiences, expectations, or context. This bias can lead to selective attention and interpretation, where individuals focus on certain aspects of a stimulus while ignoring others. For example, if a teacher expects a particular student to struggle with a subject, they may be more likely to notice and emphasize the student's mistakes, reinforcing the expectation (Bruner & Minturn, 2011). Perceptual set can influence how information is processed and how judgments are made, potentially leading to biased outcomes.

2.5.5 Enhancing Accurate Perception in Education

Given the potential for perceptual biases and errors, it is important for educators to be aware of these influences and take steps to enhance accurate perception in the classroom. Some strategies for promoting accurate perception include the following according to Bruner and Minturn (2011):

Awareness and reflection

Educators can enhance accurate perception by becoming aware of their own biases and reflecting on how these biases may influence their judgments and interactions with students. Regular self-reflection and professional development can help teachers identify and address perceptual biases.

Feedback and communication

Providing clear, specific, and constructive feedback can help students develop accurate perceptions of their abilities and performance. Open communication between teachers and students can also promote mutual understanding and reduce the impact of perceptual biases.

Cultural competence

Developing cultural competence can help educators understand and appreciate the diverse backgrounds and experiences of their students. By recognizing the influence of cultural factors on perception, teachers can create a more inclusive and equitable learning environment.

Critical thinking and perspective-taking

Encouraging students to engage in critical thinking and perspective-taking can help them recognize and overcome perceptual biases. Activities that promote empathy, open-mindedness, and the consideration of multiple viewpoints can enhance students' ability to perceive situations accurately and make informed decisions.

Data-driven decision-making

Using data and evidence to inform decisions can help educators reduce the impact of perceptual biases. By relying on objective information, such as assessment results and observational data, teachers can make more accurate and fair judgments about student performance.

In the context of this study, perception refers to how students interpret and respond to the context-based teaching approach (CBTA) used to deliver lessons on the particulate nature of matter. Since the topic of PNM is abstract and often difficult to grasp through traditional methods, how students perceive the new approach whether as clear, relatable, or effective plays a key role in shaping their learning outcomes. The study explores students' perceptions after participating in CBTA-based lessons, recognising that these perceptions provide insight into both the cognitive and emotional dimensions of their learning experience. Understanding students' perceptions also offers a more comprehensive view of the success of the teaching strategy, going beyond test scores to include students' attitudes, engagement, and sense of clarity. The insights gained from these perceptions were used to assess how well CBTA addressed the common difficulties students face in understanding particle-level concepts in chemistry.

2.6 Context-based Teaching Approach

While a variety of definitions can be attributed to the context-based approaches, it would make sense to refer to the dictionaries to explore the meaning of the word “context” as starting point. The Cambridge Advanced Learner's Dictionary (2012) defines of “context” is “the situation within which something exists or happens, and that can help explain it”. Oxford University Press (2012) defines the word with two parallel explanations;

one of which is “the circumstances that form the setting for an event, statement, or idea and in terms of which it can be fully understood” and the other is “the parts of something written or spoken that immediately precede and follow a word or passage and clarify its meaning”. The latter dictionary also provides information about the origin of the word from the late Middle English, stating that the word originated from the Latin word “contextus” from *con-* ‘together’ and *-texere* ‘to weave’. Gilbert (2006) integrates these definitions by stating that “the context must provide a coherent structural meaning for something new that is set within a broader perspective”. Context-based approaches in education primarily aim to render scientific concepts meaningful by situating them within contexts relevant to students' everyday lives. This pedagogical strategy is designed to make learning more relatable and engaging, thereby deepening students' understanding of the material. For instance, Bennett and Lubben (2006) highlight that the developers of the Salters' family of courses emphasize the importance of making young people recognize how chemistry contributes to their lives. This approach not only helps students appreciate the relevance of chemistry but also enhances their understanding of the world. Adapting this approach for Ghana, similar courses could span the entire range of secondary and pre-university education, serving as prime examples of effective context-based learning. These adapted courses will be discussed in more detail in subsequent sections.

Kortland (2005) provides another perspective by defining context as a "coherent collection of practical situations that require a deeper understanding or decisions at a personal and/or societal level." By using real-life examples such as fuel consumption, traffic safety, and the application of ionizing radiation, Kortland illustrates how physics concepts can be developed within meaningful contexts. Furthermore, he describes the curriculum in their project as being context-based, starting from the students' lived

experiences and incorporating elements of technological and natural phenomena, socio-scientific issues, and the nature of scientific inquiry.

This approach underscores the educational philosophy that learning is most effective when it is connected to the real-world experiences of students, thereby fostering a more comprehensive and applicable understanding of scientific principles.

In the case of Chemie im Kontext (ChiK), a chemistry course being applied in Germany, Parchmann et al. (2006) emphasised that “a context should enable students to see the relevance and possible application of their learning results on the one hand and to tie the new topic into their previous knowledge, interests and ideas to enable successful learning processes, in the light of constructivist learning theories, on the other hand”. Furthermore, Parchmann et al. (2006) derived three different meanings of context from the analysis of Gilbert (2006) on context definitions that should not be ignored while designing a context-based instruction. The explanations of Parchmann et al. (2006) are included below:

Context as content

The design of teaching units must connect relevant contexts, from which questions are derived, and the basic concepts that can be applied to answer such questions. Other competencies, such as the research and presentation of necessary results or experimental investigations to develop such results are included in the design of the teacher's and the students' activities.

Context as learning stimulation

Learning environments must stimulate students' mental activities to enable successful learning processes.

Context as a frame for situated development and application of knowledge and competencies:

Learning processes in class must enhance and support the (social) development of competencies, especially the transfer of learning outcomes from one unit to another.

Two aspects of context-based teaching of chemistry arise from the definitions stated so far. Firstly, the context is central to the teaching of chemical concepts. It should emphasise the relevance of the subject to students' lives by including social, economic, environmental, technological and industrial applications of chemistry (Bennett & Holman, 2002). The chemical ideas and concepts should be interwoven within the context, attributing a role to the context more than being "a mere motivational trick in the beginning to attract the students into the chemistry" (Nentwig et al., 2007). The instruction making use of contexts should seek ways of linking students' prior knowledge with the subject to be learned first, and give them a chance to raise questions regarding the features of context while proceeding along the context.

The second aspect of the context-based approach is that contexts provide students with a "need to know" basis to extend their knowledge on the subject, that is, chemical ideas and concepts are introduced when students feel a need to develop a further understanding of the features of the context being studied. Introducing concepts when they are needed helps students to see the reason for extending their knowledge and making their learning intrinsically meaningful (Beasley & Butler, 2002; Bulte et al., 2006).

2.6.1 Projects Adopting Context-Based Approaches

With the primary aim of obtaining positive student outcomes in science courses, projects designed on context-based approaches have been in widespread use around the

world from the early 1980s (Bennett et al., 2003). Several innovative projects from around the globe have been developed to address the growing concern that traditional science education does not adequately engage or relate to students. These projects are integral to this study and are extensively referred to. The following paragraphs provide an overview of seven pivotal projects, each designed to make science education more relevant and engaging:

The Salters' Approach (UK)

Initiated in the early 1980s due to concerns about the effectiveness of traditional science teaching methods, the Salters' Approach was sponsored by the Salters' Company. It offers comprehensive courses in chemistry, physics, and biology for students aged 11-18 across England and Wales. The core aim of these courses is to enhance the appeal and relevance of science by using students' everyday experiences as entry points for exploring scientific concepts. The approach includes a variety of interactive and practical learning activities to maintain student engagement and facilitate dynamic learning environments.

Chemie im Kontext (ChiK) (Germany)

Documented in 2006 by Parchmann et al., this project advocates for integrating chemistry education with real-world scenarios, thereby improving students' understanding and interest in the subject.

Chemistry in the Community (ChemCom) and Chemistry in Context (CiC) (USA)

These American projects focus on linking chemical education to real-life societal issues and practical applications, showcasing the role of chemistry in community contexts.

Industrial Science (Israel)

This initiative, spearheaded by Hofstein and colleagues, aims to bridge the gap between science education and industrial applications, providing students with practical insights into the use of science in various industries.

Chemistry in Practice (ChiP) and Physics Curriculum Development Project (PLON) (Netherlands)

These projects emphasize the practical application of chemistry and physics, enhancing students' problem-solving skills and understanding of real-world issues through hands-on activities.

Each project underscores the philosophy that science education is most effective when it connects with students' real-world experiences. By focusing on practical applications and societal relevance, these initiatives strive to deepen students' understanding of scientific principles and inspire a greater appreciation for the impact of science on everyday life. This approach not only makes learning more meaningful but also aims to cultivate a more engaging and inclusive science education environment.

2.6.2 Theories Underlying Context-based Education

This part of the study aims to shed light on the theories mentioned by the developers of projects adopting context-based approaches to science teaching and can be considered an organization of knowledge and a means to enhance the understanding of the theory and the philosophy behind the context-based approaches. To achieve this aim, studies elaborating on the development of projects adopting context-based approaches in teaching are analysed in detail. This analysis revealed that several of the context-based projects started with a pre-determined theoretical background whereas the development of the rest of the projects under consideration was not based on a theory but was driven

primarily by the experiences of practitioners and their ‘craft’ knowledge (Brown & McIntyre, 2013), or stemmed from problems faced during actual classroom practices.

ChiK is one of the projects that have a pre-determined theoretical background. Nentwig et al., (2005) proposed three theoretical considerations for explaining the philosophy of the project which are “scientific literacy”, “theories of motivation” and “theories of constructivism”, in particular; situated learning and conceptual change models (p.156).

A relatively small-scale project, a Design-Based Science curriculum, implemented in US and Israeli high schools also have a pre-determined theoretical base which focuses on the principles of “social constructivism” characterized by “active construction” and “situated cognition”, being the two main learning features of the project (Mamlok-Naaman et al., 2005). Likewise; the Swedish science curriculum, which follows the traditions of context-based approach, reflects “the theory of learning based on Vygotsky” by placing knowledge acquisition in a sociocultural context (Szybek, 2005). The Partnership Industry and School (PaIS) project that was developed for chemistry lessons implemented in German secondary schools also based its framework on five interrelated theoretical considerations: “scientific literacy”, “self-regulated learning”, “cognitive apprenticeship”, “resource-based learning” and “mind-mapping” (Graber et al., 2005).

From a broader point of view, Gilbert (2006) emphasizes three approaches that have particular importance for the use of contexts in teaching which are constructivism, situated learning, and activity theory.

Constructivists believe that students construct their knowledge through experience, things and reflecting on those experiences based on their prior knowledge and transferring their knowledge to new situations by relating the new knowledge with their

previous ideas and experiences (Berns & Erickson, 2001). Context-based approaches use the real-world experiences of students as a foundation for introducing scientific concepts, offering authentic learning activities that promote the development of higher-order thinking skills from a constructivist perspective. Reinmann-Rothmeier and Mandl (2001, as cited in Mandl & Kopp, 2005) identify "situative" learning as one of the six key characteristics of constructivist learning, emphasizing that knowledge acquisition is closely linked to specific situations. This approach ensures that learning is relevant and deeply connected to real-life contexts, enhancing the educational experience by making it more meaningful and applicable.

Activity theory has a notable point of view for context; it regards the components of the activity; like objects, actions, and operations, as being the context itself without thinking the learner and the object being studied as separate entities (Vygotsky, 1978 as cited in Gilbert, 2006). Moreover; context is not something isolated from the activities people take part with their objects. The reflection of activity theory on classroom practice is cognitive apprenticeship aiming to guide and support learners throughout the problem-solving process as is the case in context-based instruction.

2.6.3 Characteristics of a Context-based Instruction

For instructional practices to be considered context-based, there are no well-defined explicit steps to follow in the classroom. However, there is an underlying philosophy behind context-based approaches which imply the characteristics of context-based instruction.

Berns and Erickson (2001) highlight several critical aspects to consider for effective context-based instruction. Teachers should carefully design lesson plans that account for the social, emotional, and intellectual growth of their students. This includes

fostering group work to enhance peer learning and encouraging students to understand their own learning styles, strengths, and weaknesses to promote self-regulated learning. It's also essential to choose instructional contexts that acknowledge and respect students' diverse backgrounds and minimize biases, particularly regarding gender. Moreover, educational activities should cater to various intelligence types to address the varying abilities within a classroom.

Further enhancing this educational approach, assessments should focus on students' ability to apply knowledge rather than simply recalling facts, thereby supporting the development of higher-order thinking and problem-solving skills. To provide a clearer understanding of the application of these principles, Nentwig et al. (2005) outline the four stages of a Chemie im Kontext (ChiK) unit: the contact phase, curiosity and planning phase, elaboration phase, and nexus phase. Each stage plays a pivotal role in deepening students' engagement and comprehension during context-based instruction.

In the contact phase; the context that is expected to capture students' interests is presented to students use familiar materials like newspapers and photographs as an introduction to the chemistry topic. The curiosity and planning phase is generally based on students' questions about the context. They raise the questions that they seek for the answers and the teacher guides them to structure their questions focusing on the chemistry subject.

During the elaboration phase, the aim is to find answers to the questions raised during the previous phase by involving students in group activities. The role of the teacher becomes a scaffolder of the process. The students may consult a wide range of resources for gathering information to be able to find answers to the questions. In the end, they are expected to present their findings to the class.

2.6.4 Implementation of Context-Based Teaching in Science Education

The implementation of context-based teaching strategies in science education has been widely studied, with research indicating positive outcomes across various scientific disciplines (Bulte et al., 2006; Gilbert, 2011). In practice, these strategies involve selecting contexts that are relevant and engaging to students, designing instructional activities that integrate these contexts with scientific content, and assessing students' ability to apply their knowledge in new and unfamiliar situations.

One of the challenges in implementing context-based teaching is ensuring that the contexts used are both scientifically accurate and pedagogically appropriate (Bennett et al., 2010). Teachers must carefully select contexts that not only resonate with students but also effectively illustrate the scientific concepts being taught. This requires a deep understanding of both the subject matter and the students' interests and backgrounds (King & Ritchie, 2013).

Moreover, the success of context-based teaching depends on the teacher's ability to facilitate meaningful learning experiences. Teachers must be able to guide students in making connections between the context and the scientific content, encouraging them to think critically and to apply their knowledge in novel situations (Bulte et al., 2006). Professional development programs that focus on context-based teaching strategies can help teachers develop these skills, ensuring that they are well-equipped to implement this approach in their classrooms (Van Driel & Berry, 2012).

In addition to teacher training, the development of instructional materials that align with context-based approaches is crucial for successful implementation (Bennett et al., 2010). These materials should be designed to support the integration of context and

content, providing students with opportunities to explore scientific concepts within relevant and meaningful scenarios. For example, a chemistry textbook might include case studies on the environmental impact of chemical processes, allowing students to apply their knowledge of chemical reactions to real-world problems (Gilbert, 2011).

2.6.5 The Ghanaian Educational Context

The Ghanaian educational system, like many in sub-Saharan Africa, faces numerous challenges in the implementation of science education. These challenges include limited resources, large class sizes, and a reliance on traditional teaching methods, which can hinder the adoption of innovative teaching strategies such as context-based teaching (Adams & Opoku-Asare, 2021).

Despite these challenges, there is growing recognition of the potential benefits of context-based teaching for improving student outcomes in science education in Ghana (Agyei & Voogt, 2011). Implementing context-based teaching in Ghana presents several challenges, including the need for adequate teacher training, the development of appropriate teaching materials, and the alignment of the curriculum with context-based approaches.

Teacher training is a critical factor in the successful implementation of context-based teaching. According to Osei-Poku and Gyasi (2020), many teachers in Ghana are not familiar with context-based approaches and may lack the skills needed to integrate real-world contexts into their teaching. Professional development programs that focus on context-based teaching strategies can help to address this gap, providing teachers with the knowledge and tools they need to effectively implement this approach in their classrooms.

The development of teaching materials that align with context-based approaches is another important consideration. In many Ghanaian schools, textbooks and other instructional materials are designed for traditional, content-focused teaching and may not provide the contexts needed to support context-based learning (Adams & Opoku-Asare, 2021). Developing new materials that incorporate relevant contexts and that are accessible to both teachers and students is essential for the success of context-based teaching (Agyei & Voogt, 2011).

Finally, the alignment of the curriculum with context-based approaches is necessary to ensure that students are assessed on their ability to apply scientific concepts in real-world contexts, rather than simply on their recall of factual information (Asabere-Ameyaw et al., 2012). This alignment requires collaboration between educators, curriculum developers, and policymakers to ensure that the goals of context-based teaching are reflected in the curriculum and in national assessments (Boakye & Ampiah, 2017).

This study aims to contribute to this growing body of knowledge by exploring the effectiveness of context-based teaching in improving students' understanding of complex scientific concepts in a Ghanaian senior high school. By examining the challenges and successes of implementing this approach in a specific context, the study provides valuable insights for educators and policymakers working to improve science education in Ghana and similar settings.

2.7 Gender Differences in Science Education

Gender differences in science education have been the subject of considerable research, with studies examining differences in performance, attitudes, and participation across

various scientific disciplines. Understanding these differences is crucial for developing teaching strategies that are inclusive and equitable, ensuring that all students have the opportunity to succeed in science education (Ceci & Williams, 2011).

2.7.1 Research on Gender Differences in Science Education

Research has shown that gender differences in science education are complex and multifaceted, with disparities varying across different scientific disciplines and educational contexts. For example, studies have found that boys tend to outperform girls in physics and engineering, while girls often perform better in biology and environmental science (Watt et al., 2012; Else-Quest et al., 2013).

However, these differences are not solely due to innate abilities but are influenced by a range of social, cultural, and educational factors (Hyde & Linn, 2016). For instance, societal stereotypes about gender and science can influence students' attitudes and self-perceptions, leading to differences in performance and participation (Cheryan et al., 2017). Girls may be less likely to pursue science subjects if they perceive them as "male" domains or if they lack female role models in the field (Sadler et al., 2012).

Moreover, research has shown that gender differences in science education can be mitigated by teaching strategies that emphasize collaboration, hands-on learning, and real-world applications (Archer et al., 2013). For example, a study by Wang and Degol (2017) found that when science lessons were designed to be more interactive and relevant to students' lives, girls' interest and performance in science improved significantly.

Recent research has also explored the impact of digital tools and online learning platforms on gender differences in science education. For example, a study by Master

et al. (2016) found that girls were more likely to engage with science content when it was presented in a collaborative, game-based format, suggesting that technology can play a role in reducing gender disparities in science education.

2.7.2 Gender and Context-Based Teaching

The impact of context-based teaching on gender differences in science education has been explored in several studies, with findings suggesting that this approach can help to reduce gender disparities in performance and participation (Bennett et al., 2010). Context-based teaching strategies, which emphasize real-world applications of scientific concepts, can make science more accessible and engaging for all students, regardless of gender (King & Ritchie, 2013).

A study by Bennett et al., (2010) found that context-based teaching reduced the gender gap in student performance, particularly in areas where girls typically underperformed. This suggests that making science more relevant to students' lives can help to engage both boys and girls equally and improve their understanding of the subject. Similarly, a study by King and Ritchie (2013) found that girls who were taught using context-based approaches were more likely to develop positive attitudes toward science and to see it as relevant to their future careers.

The effectiveness of context-based teaching in reducing gender differences may be due to its emphasis on collaboration and hands-on learning, which have been shown to benefit both boys and girls (Archer et al., 2013). For example, in a lesson on environmental science, students might work together to analyse the impact of pollution on local ecosystems, thereby applying their knowledge of scientific principles in a collaborative and meaningful context. This approach not only enhances students'

understanding of science but also fosters a sense of community and shared responsibility for learning (Sadler et al., 2012).

In the context of this study, it is important to explore how context-based teaching affects male and female students differently, particularly in terms of their engagement, understanding, and performance in science. Understanding these differences can help educators develop more effective teaching strategies that are inclusive and equitable, ensuring that all students have the opportunity to succeed in science education.

2.8 Empirical Review of Related Studies

In this subsection, existing research and studies related to the topic under investigation were reviewed to provide a comprehensive understanding of the current knowledge base. The following were the topics that were reviewed.

2.8.1 Students' Existing Conceptions about the Particulate Nature of Matter

A firm grasp of the particulate nature of matter (PNM) is central to students' understanding of a wide range of chemistry and science concepts, including states of matter, phase transitions, chemical reactions, and bonding. Despite its foundational importance, a significant body of research has shown that students across different educational levels continue to harbour deep-rooted misconceptions about the structure and behaviour of matter at the particle level (Nakhleh & Samarapungavan, 2012; Driver et al., 2014; Ozmen & Kenan, 2007). These misconceptions often persist even after formal instruction, thereby affecting students' ability to meaningfully engage with more complex chemistry topics. This section critically reviews existing empirical studies that have investigated students' conceptions about the particulate nature of matter and demonstrates how these insights informed the first phase of the present study.

Students' pre-existing ideas play a significant role in shaping how they interpret and internalise new scientific concepts. According to constructivist learning theories (Driver et al., 2014), learners bring with them a set of intuitive understandings formed through everyday experiences, language, and cultural exposure. These informal ideas often conflict with scientific explanations and must be actively reconstructed through instruction. Studies such as those by Driver et al. (2014) and Ayas et al. (2010) have found that many students view matter as continuous and homogeneous rather than as composed of discrete, interacting particles. These alternative conceptions interfere with students' ability to explain common phenomena such as phase changes, diffusion, and the conservation of mass.

A notable example is the misconception that gases are "weightless" or "do not occupy space". Merritt et al. (2008) and Séré (2008) documented how many learners, including secondary school students, failed to attribute mass to gaseous substances, often stating that air has no weight because it cannot be felt. This belief directly contradicts the scientific principle that all matter, regardless of its state, has mass and volume. Similarly, students often assume that when a substance undergoes evaporation or sublimation, the particles disappear or transform into "nothingness", revealing a limited understanding of particle conservation and energy transfer. These misconceptions are further reinforced by the limitations of classroom instruction that relies heavily on textbook explanations and symbolic representations, without providing concrete visual or contextual links to everyday life.

Studies by Nakhleh and Samarapungavan (2012) and Liu and Lesniak (2005) revealed that misconceptions about matter are not confined to lower educational levels. Even students at the tertiary level struggle with interpreting symbolic notations and visualising the sub-microscopic nature of matter. Liu and Lesniak proposed a model of

conceptual progression involving five overlapping waves that students must pass through to achieve a complete understanding of matter. The first stages involve general observable properties, while later stages demand an understanding of bonding theories, particle movement, and interactions. However, their findings also suggest that many students do not follow this idealised path smoothly and tend to plateau at intermediate stages due to cognitive overload and abstract content delivery.

These findings are consistent with observations made in Ghanaian classrooms, where the traditional mode of instruction often neglects the role of students' prior knowledge in lesson planning. During the preliminary phase of the current study at Mozano College of Music, students were asked to explain simple everyday processes, such as the spreading of perfume or the formation of steam. Their responses revealed common misconceptions such as "particles grow wings to fly," or that "particles only move when they are hot." Other students believed that particles in solids are fixed and cannot vibrate, or that gases are empty spaces between liquids and solids. These insights confirmed the presence of alternative conceptions about PNM and highlighted the urgent need for instructional interventions that actively target these misunderstandings. Several researchers have attempted to categorise these misconceptions. For example, Taber (2009) identified implicit knowledge elements that contradict formal science instruction. These include intuitive beliefs such as "smaller means lighter" or "if I cannot see it, it must not exist". These beliefs interfere with the formal understanding of atoms, molecules, and subatomic interactions. Boz (2006) also observed that students struggle with visualising particle movement in solids and liquids. Many believed that particles in a solid are completely motionless, which is inaccurate as particles in solids vibrate around fixed positions due to thermal energy. This misconception hinders students' ability to explain phenomena like thermal expansion and conduction.

Another layer of difficulty arises when students are required to interpret symbolic or diagrammatic representations of matter. According to Treagust et al. (2002), students often misread particle diagrams, mistaking them for literal representations rather than models. For instance, they may interpret circles drawn close together as static objects, failing to understand that the diagram represents the relative closeness and movement of particles. This finding is particularly relevant to this study, as some students during the pre-test phase could not distinguish between a symbol representing an atom and a real object. While the current study did not directly compare conceptual understanding across educational levels, the findings of Treagust et al. (2002) reinforce the need to address such visual and symbolic barriers in classroom instruction.

It is also worth noting that some literature tends to focus more on teachers' understanding of PNM, such as the work by Valanides (2000) and Nakiboglu (2003). However, since the present study is focused on students, these studies were only referenced briefly to demonstrate that misconceptions about PNM are pervasive, even among educators. The main emphasis remains on learners' difficulties, as supported by evidence gathered during the diagnostic phase of this research.

The review of these empirical studies provides compelling justification for the approach adopted in this research. It confirms that traditional methods of instruction are insufficient for correcting entrenched misconceptions about PNM and that instructional strategies must take into account students' prior knowledge and lived experiences. Therefore, the context-based teaching approach adopted in this study was designed not only to improve students' academic performance but also to reconstruct their conceptual frameworks by building upon what they already know.

This section has established that the first objective of this study examining students' existing conceptions about the particulate nature of matter is both theoretically and

practically justified. Identifying these conceptions provided the foundation for developing a relevant and targeted teaching intervention to improve understanding of PNM among senior high school students in Ghana.

2.8.2 The Effect of Context-Based Teaching on Students' Academic Performance in Science

The role of instructional strategies in shaping students' academic performance has long been a focus of science education research. Among these strategies, context-based teaching has emerged as a powerful alternative to traditional methods, particularly for promoting conceptual understanding and improving achievement in abstract science topics such as the particulate nature of matter (PNM). Numerous empirical studies have shown that when scientific concepts are introduced through familiar, real-life contexts, students are better able to connect new information with their prior knowledge, leading to improved retention, deeper understanding, and enhanced academic performance (Barineka and Avwiri, 2014; Danis et al., 2017; Ahmed, 2017).

The effectiveness of context-based teaching has been attributed to its grounding in constructivist learning theory. This approach positions students as active participants in their own learning process, encouraging them to build knowledge through exploration, interaction, and reflection. In this model, learners are presented with scientific problems situated in everyday contexts that they can relate to, which in turn motivates them to engage more deeply with content. Rather than simply memorising facts, students are encouraged to apply their understanding to solve practical problems, thereby enhancing their grasp of core scientific ideas.

Barineka and Avwiri (2014), for instance, conducted a quasi-experimental study involving 451 Senior High School students in Nigeria to investigate the effectiveness of context-based teaching in inorganic chemistry. The students were divided into

control and experimental groups, with the latter exposed to everyday scenarios such as water purification, food preservation, and the use of household substances. The findings revealed a statistically significant improvement in the academic performance of students in the experimental group compared to those taught through the traditional expository approach. Notably, the researchers found no significant gender differences in performance, suggesting that context-based methods are effective for a broad range of learners. However, they reported that rural students outperformed their urban counterparts, possibly due to the higher relatability of the rural contexts used in instruction. This finding highlights the importance of selecting locally meaningful contexts in designing science lessons.

In a similar study, Ahmed (2017) investigated the impact of a context-based instructional approach on the performance of Senior Secondary students learning hydrocarbon concepts. The study, which involved 120 students in Kano State, Nigeria, employed a pre-test, post-test control group design. The results showed that students in the context-based group performed significantly better than those taught through conventional lecture methods. The Chemistry Achievement Test (CAT) used in the study had a high reliability coefficient of 0.85, lending credibility to the findings. Ahmed concluded that the context-based approach helped bridge the gap between theoretical content and students' real-life experiences, thereby enhancing their understanding and academic achievement.

Research by Danis et al. (2017) also supports these conclusions. Their study focused on Grade 7 students in Indonesia and explored the use of a Context Based Teaching Approach (CBTA) in science instruction. The experimental group was taught through scenarios such as the evaporation of sweat, the movement of perfume in air, and the behaviour of water during boiling. Post-test scores indicated that students in the Context

Based Teaching Approach group significantly outperformed those in the control group. The study concluded that contextual teaching not only improved content mastery but also fostered greater classroom participation and motivation. Although this study was conducted at the junior high school level, its findings are highly relevant to the present research, which also uses real-life contexts to teach PNM at the Senior High School level.

In the Ghanaian context, limited studies have been conducted on the use of context-based teaching in science education. However, Agyei (2020) investigated its impact in genetics instruction and found that students exposed to real-life scenarios performed better and expressed greater interest in the subject. This underscores the importance of aligning science instruction with learners' everyday realities to promote meaningful learning. Given the cognitive challenges associated with understanding particle behaviour and sub microscopic processes, context-based teaching provides an opportunity to make invisible concepts visible through analogy, simulation, and practical observation.

In the current study, students at Mozano College of Music were introduced to a series of lessons on the particulate nature of matter that integrated relatable contexts such as the diffusion of perfume, steam formation during ironing, and condensation on cold drink bottles. These scenarios were chosen not only for their relevance but also for their potential to prompt scientific reasoning rooted in everyday experience. The results of the intervention showed clear improvements in students' academic performance as measured by pre-test and post-test scores. The post-test indicated stronger conceptual understanding and fewer misconceptions, particularly in areas related to particle movement, phase changes, and spacing between particles in different states of matter.

In conclusion, the literature strongly supports the use of context-based teaching as a means of improving students' academic performance in science. The reviewed studies consistently show that when scientific content is anchored in familiar and meaningful contexts, learners are more likely to engage with the material, understand complex concepts, and retain what they have learned. The findings from the present study are consistent with this body of research, demonstrating the effectiveness of context-based instruction in enhancing students' academic performance in the topic of PNM at the SHS level in Ghana.

2.8.3 Gender Differences in Students' Academic Performance in the Particulate

Nature of Matter

Gender differences in academic performance, particularly in science subjects, have long been a subject of empirical investigation. Various studies have examined whether male and female students perform differently in science and, if so, what factors contribute to these differences. In the context of the particulate nature of matter (PNM), understanding gender-related performance patterns is important for informing inclusive teaching practices and for addressing any underlying disparities that may affect learners' academic success. This section reviews relevant studies that have explored gender differences in science performance and relates their findings to the current study, which examined how male and female students responded to the context-based teaching approach (CBTA) in learning PNM.

Several international studies have reported mixed findings regarding gender and science achievement. While some researchers argue that males tend to outperform females in science and mathematics-related subjects, others contend that gender differences are diminishing and often context-specific (Bennett & Hogarth, 2009).

Factors such as classroom environment, teaching method, societal expectations, and self-efficacy beliefs are all known to influence performance outcomes across genders.

In a quasi-experimental study by Barineka and Avwiri (2014), the researchers investigated the effect of a context-based teaching strategy on students' academic performance in inorganic chemistry. The study, which involved 451 Senior Secondary students in Nigeria, revealed no statistically significant difference between the performance of male and female students taught using the context-based strategy. This finding suggests that the CBTA is a gender-neutral approach that benefits learners regardless of their sex. The researchers concluded that when science is taught in ways that are meaningful and relatable, both boys and girls can perform equally well.

Similarly, Achor (2024) conducted a study in Taraba State, Nigeria, to examine the impact of context-based learning strategies on students' achievement in physics. The findings revealed that students taught using CBTA performed significantly better than those taught using conventional methods. Importantly, no significant difference was observed between male and female students in the experimental group. This reinforces the idea that instructional approach, rather than gender, plays a more critical role in determining academic outcomes in science.

In Ghana, studies on gender disparities in science performance have also yielded varied results. While national statistics sometimes show male dominance in science-related achievement, these differences tend to shrink when contextual or learner-centred approaches are employed. Agyei (2020), for example, examined gender differences in the performance of students taught genetics through a context-based method. The study reported no significant difference in performance between male and female learners, suggesting that contextualising content can create a level playing field by engaging both genders equally.

The present study contributes to this body of knowledge by examining whether gender had any significant effect on students' academic performance after being taught PNM through the CBTA. The pre-test scores showed marginal differences between male and female students, while post-test results revealed a general improvement for all students, with no statistically significant gender-based disparity. This suggests that the CBTA was effective in enhancing learning for both male and female students, possibly due to the approach's use of real-life scenarios that are familiar to all students, regardless of gender.

In addition, qualitative data gathered through classroom observations indicated that both male and female students actively participated in CBTA lessons. Girls, who are often less vocal in science classrooms, were seen contributing to discussions, asking questions, and explaining concepts using contextual examples. This reflects the finding of Yilmaz and Koral (2017), who noted that when science content is situated in meaningful contexts, gender-related participation gaps are reduced.

Nevertheless, some researchers argue that while performance differences may not be statistically significant, subtle gender biases still exist in science instruction. These include the choice of examples, teacher expectations, and classroom dynamics, which can influence how boys and girls perceive their competence. Therefore, continued attention to gender-sensitive instructional design remains important, even when adopting seemingly inclusive approaches like CBTA.

In conclusion, the review of literature suggests that context-based teaching strategies have the potential to minimise or eliminate gender differences in science achievement. When instruction is delivered in a way that is relevant, interactive, and reflective of students' real-life experiences, both male and female students tend to benefit equally. The current study confirmed this by showing that CBTA had a positive impact on the

academic performance of students in PNM without favouring one gender over the other. This finding reinforces the call for adopting context-rich instructional strategies that promote equity and inclusion in science education.

2.8.4 Students' Difficulties in Understanding the Particulate Nature of Matter

In science education, the perception students hold toward a particular instructional approach significantly influences their engagement, interest, and overall learning outcomes. When students perceive a teaching method as relatable, enjoyable, and helpful in deepening their understanding, they are more likely to participate actively and retain knowledge over time. The Context-Based Teaching Approach (CBTA), which integrates everyday scenarios into science lessons, has been shown in various empirical studies to enhance not only performance but also students' attitudes and perceptions toward science learning. This section reviews literature relevant to how students perceive CBTA in relation to learning abstract concepts, particularly the particulate nature of matter (PNM).

Science topics like the PNM are notoriously difficult for students to grasp due to their abstract and sub-microscopic nature. Learners are expected to visualise particles in motion, interpret diagrams, and understand symbolic representations that cannot be observed directly. These cognitive demands often result in disengagement, misconceptions, and a lack of enthusiasm for science. Researchers such as Plumley et al. (2016) and Singer et al. (2003) have reported that students find topics involving particles, phase changes, and molecular motion difficult and confusing when taught using conventional lecture-based methods. These difficulties highlight the need for teaching strategies that not only clarify content but also reshape students' perceptions of science as an accessible and relevant subject.

Studies conducted in various educational contexts have consistently shown that when science concepts are delivered using real-life examples and familiar scenarios, students respond more positively to instruction. Singer et al. (2003), in their work on project-based science instruction, found that students reported greater enjoyment and engagement when lessons involved investigations based on everyday phenomena. Students appreciated being able to relate particle-level concepts to observable events such as boiling water or the spreading of scent, which helped them to understand the movement of particles in different states. Similarly, Carr et al. (2013) observed that students perceived science lessons as more enjoyable and less intimidating when taught through inquiry and context-based tasks.

In the Ghanaian setting, where science is often perceived as a difficult and abstract subject by many secondary school students, context-based teaching offers a promising alternative. The present study investigated how students at Mozano College of Music perceived the CBTA during lessons on PNM. Students expressed in interviews that they found the context-based lessons more interactive and less stressful compared to conventional methods. They explained that relating particle movement to real-life events, such as the formation of mist on cold bottles or the spreading of perfume, made the topic more “real” and “understandable”. These perceptions reflect the growing evidence that when students can connect classroom content to their lived experiences, their attitudes toward science improve significantly.

Research by Kose and Tosun (2015) supports this observation. Their study examined students’ attitudes toward chemistry following instruction based on context-based approaches. Students in the experimental group reported higher interest in the subject, a better understanding of the content, and greater willingness to participate in class. Qualitative responses gathered through interviews indicated that learners appreciated

the use of familiar situations, which helped reduce their anxiety and increased their motivation to learn.

The current study also observed that the use of CBTA encouraged participation among students who were typically quiet during science lessons. Some students reported that they felt more confident answering questions when they could relate the topic to something they had experienced before. This finding is consistent with those of Yilmaz and Koral (2017), who found that context-based teaching reduces intimidation and supports inclusion by allowing all students, regardless of academic background, to find relevance in science content.

Another important perception identified during the study was that students viewed CBTA as a more “practical” way of learning science. They indicated that traditional lessons often involved memorising definitions and equations, which they struggled to understand or remember. By contrast, CBTA allowed them to explain what they observed in daily life using scientific reasoning. This shift in perception from science as something abstract to something applicable is a critical step in fostering lifelong scientific literacy.

In conclusion, the literature and findings of the present study confirm that students perceive the Context-Based Teaching Approach as an effective and engaging method for learning difficult science topics such as the particulate nature of matter. Positive perceptions were associated with increased participation, motivation, and confidence in learning. By integrating relevant, familiar contexts into instruction, CBTA not only improves academic performance but also transforms students’ attitudes toward science, making it more accessible and meaningful.

2.9 Summary of this Chapter

This chapter presented a detailed review of the relevant theoretical, conceptual, and empirical literature that informed the present study. The constructivist theory of learning, which underpins the study, highlights the significance of learners actively constructing meaning through experiences that connect to their prior knowledge. In line with this perspective, the chapter explored the principles of the Context-Based Teaching Approach (CBTA), with particular attention to its application in science education and its role in promoting meaningful learning.



CHAPTER THREE

METHODOLOGY

3.0 Overview

The chapter provides an insight into the methodology employed in the study, encompassing the research approach and design. It delves into key aspects such as the study population, sampling methods, and the research instrument utilized for data collection. Validity and reliability of the instruments are scrutinized, alongside pre-intervention, intervention, and post-intervention activities. The chapter also outlines the data analysis procedure and ethical considerations guiding the research process.

3.1 Research Design

This study employed a mixed-methods approach, integrating both quantitative and qualitative strategies to gain a comprehensive understanding of students' academic performance in the particulate nature of matter. The design adopted was action research, which allowed the researcher to implement, observe, and reflect on a context-based teaching intervention within a real classroom setting. This design was appropriate because it enabled practical improvements in the teaching and learning process while generating empirical evidence (Creswell, 2014; Cohen et al, , 2017).

3.2 Population

A research population is generally a large collection of individuals or objects that was the main focus of scientific inquiry, and it is for the benefit of the population that research is conducted (Johnson & Christensen, 2019). The population of the study included all students of Mozano College of Music School, Mozano comprising 795 students (484 males and 311 females).

The target population for the study comprised all second-year General Arts students in Mozano College of Music Senior High Schools. The accessible population, however, was limited to Form Two General Arts students at Mozano College of Music Senior High School, due to proximity, accessibility, and administrative approval. By narrowing the population, the researcher ensured better control over the intervention and data collection process.

3.4 Sampling and Sampling Technique

The study employed a purposive sampling technique, specifically selecting an intact class of Form Two Science students at Mozano College of Music Senior High School. This method was chosen because the selected students had been introduced to the concept of the Particulate Nature of Matter but had shown conceptual gaps in previous assessments and class interactions. The purposive sampling ensured that participants were not only accessible and available but also relevant to the research objectives.

This intact class was made up of 37 students, consisting of both male and female learners. The purposive sampling ensured that all students were exposed to the same instructional content, environment, and teacher before and during the intervention, thus reducing variability in instructional delivery. Furthermore, the sampling technique enabled the researcher to implement the intervention efficiently within the natural school timetable, minimizing disruption to the academic calendar.

This choice of sampling aligns with Creswell (2014), who notes that purposive sampling is appropriate in educational interventions when researchers aim to gain insights from specific participants who possess particular characteristics relevant to the study.

To gather qualitative data on students' perceptions of the context-based teaching approach, six students were selected for interviews using a lottery method. This sampling size was determined based on the principle of data saturation in qualitative research, where data collection continues until no new information is obtained (Guest et al., 2006).

Considering the small class size of 30 students, selecting six (20%) provided a manageable yet diverse representation of the class for in-depth exploration. The lottery method ensured equal opportunity for each student to be selected, thus minimizing bias in participant selection.

Additionally, the chosen sample size aligned with qualitative research norms, where a smaller number of participants is sufficient for thematic analysis, especially when responses are rich in detail (Creswell, 2014). This allowed the researcher to gain detailed insights into how students experienced and perceived the context-based teaching intervention.

3.5 Research Instruments

The research instruments that were used in the study for data collection are a pre-intervention test, a post-intervention test and a semi-structured interview.

3.5.1 Tests

According to Frankel et al. (2012), a test can be used as a means to measure an individual's knowledge in a given area or subject to assess the effectiveness of a program. Two tests were administered: The pre-test (administered before the intervention) consisting of 5 essay-type items was used to collect quantitative data on students' academic performance before and data on students' prior conceptions of

particulate nature of matter A sample of the pre-test with its respective marking scheme can be found in Appendix A and B.

The pre-intervention and post-intervention tests were designed to assess students' understanding of core concepts related to the particulate nature of matter (PNM). These instruments served as the primary tools for measuring changes in students' academic performance before and after the implementation of the context-based teaching approach.

Both the pre-test and post-test covered the same content areas to ensure consistency and comparability. The tests included questions on the following key topics; The basic structure of matter, Properties and arrangement of particles in solids, liquids, and gases Particle movement and spacing in different states of matter, Phase changes, including evaporation, condensation, melting, and freezing Each test was composed of a short-answer items aimed at evaluating not only factual recall but also conceptual understanding and the ability to explain observable phenomena using particle-level reasoning. The design of the items sought to identify common misconceptions and assess the depth of students' understanding of the PNM topic.

The pre-test was administered prior to the intervention to establish students' baseline understanding of the topic, while the post-test was given after the intervention to determine the extent of conceptual improvement following the context-based teaching approach. A sample of the pre-intervention and post-intervention tests is provided in Appendices C and D respectively.

3.5.2 Interview Schedule

In this study, a semi-structured interview schedule consisting of seven open-ended questions was developed by the researcher to explore students' perceptions of the context-based teaching approach (see Appendix E for the full interview schedule). These questions focused on how students experienced the lessons, what aspects of the context-based approach helped their learning, and any challenges they faced. The semi-structured format ensured that key topics were covered while allowing students the freedom to express their thoughts in detail. Each interview was conducted in person, approximately 15 minutes long, and audio-recorded with permission.

3.6 Validity of Research Instruments.

To ensure both content and face validity of the research instruments, a rigorous review process was undertaken involving two Integrated Science teachers from Mozano College of Music and the researcher's academic supervisor. These reviewers were chosen based on their subject expertise and familiarity with the SHS science curriculum, particularly in relation to the Particulate Nature of Matter (PNM).

3.6.1 Content Validity

The content validity of the test items and interview schedule was established through expert review. The reviewers examined each item for its relevance to the objectives of the study and the extent to which it reflected the key concepts under the PNM topic.

During the review of the pre-test (Appendix A), it was noted that certain questions lacked focus on real-life applications, which are essential in a context-based teaching approach. For example; Original Item (Q4): *"How do atoms combine to form molecules?"* This was considered too broad. It was revised in the post-test (Appendix C) to; *"Explain the role of intermolecular forces in determining the properties of solids"*

and liquids. “This revision encouraged students to connect their knowledge to observable properties of matter.

The reviewers also recommended adding a question on phase change to assess students’ ability to relate microscopic behaviour to everyday experiences. As a result, a new item was added; *“Explain the process of sublimation and provide an example of a substance that undergoes it.”*

3.6.2 Face Validity

To establish face validity, the same science teachers and the supervisor examined the instruments for clarity, wording, and appropriateness for SHS students.

Some items were considered too technical or vague for the target group. For instance:

Original Question (Q5): *“How does an atom become an ion?”*

This was reworded to; *“Describe how ions are formed and give examples of a cation and an anion.”*

The addition of examples made the question clearer and more approachable for students. In the interview schedule (Appendix E), the item: *“How did the context-based approach influence your critical thinking and problem-solving skills?”* Was revised for simplicity to: *“Can you describe one topic you understood better because of the context-based lessons?”* “This made it easier for students to relate their learning experiences without needing to understand technical terms.

The feedback also led to general improvements in the layout of the test and interview documents, including better spacing and clearer instructions to reduce confusion during administration. These steps helped to ensure that the instruments were clear, relevant, and aligned with both the learning goals of the study and the cognitive level of the students at Mozano College of Music.

3.7 Reliability of Research Instruments

Instruments were trial tested on students of the same characteristics in a different class of the same school who are not part of the main study. The instruments were administered to the participants of the trial test twice. The time gap between the two administrations of the instruments was one week. The duration of one week was thought sufficiently long for the participant not to remember their previous responses (in the first administration of the instruments). Data from the first and second administrations of the instruments were used to compute the reliability of the instruments.

To establish the reliability of the test instruments used in this study, the Cronbach's Alpha method was employed. Cronbach's Alpha is a measure of internal consistency, which evaluates how closely related a set of items are as a group (Tavakol & Dennick, 2011). It is widely used in educational research to determine the reliability of scales and tests involving multiple items that assess the same construct. The reliability coefficients obtained were 0.72 for the pre-test and 0.76 for the post-test. These values are considered acceptable for research purposes and indicate that the test items were internally consistent. Determination of the values obtained can be found in Appendix F.

To ensure the reliability of the interview data, the interview responses were independently coded by two interviewers using a common framework aligned to the research objectives. Each student's answers to seven interview questions were categorised as indicating either a positive or negative perception of the context-based teaching approach. Cohen's Kappa coefficient was calculated to assess inter-rater agreement and yielded a value of 0.743, indicating substantial reliability. A summary of the coded responses and the calculation of Cohen's Kappa is presented in Appendix G.

3.8 Data Collection Procedure

Data was collected in the following ways:

3.8.1 Pre-intervention Activities

In preparation for the study, the researcher designed a pre-test aimed at assessing the initial conceptions and academic performance of the participants concerning the particulate nature of matter. This pre-test, which consisted of five essay-type questions, was administered to the research sample. The participants were given 45 minutes to complete the test.

During the first week of the study, the pre-test was conducted to determine the participants' prior understanding of the particulate nature of matter. Additionally, it served to document their academic performance in this area before any intervention was introduced. After the test, the completed scripts were collected for further analysis.

3.8.2 Intervention Activities

Lesson plans were designed for four weeks with two-hour lessons each week based on the implementation of a context-based teaching approach in teaching particulate nature of matter. The lessons were designed to be interactive and to connect scientific concepts to everyday experiences, thereby making the content more relevant and engaging for students.

3.8.3 Implementation of the Context-Based Teaching Approach

The instructional strategy used for the intervention in this study was the Context-Based Teaching Approach (CBTA). This approach was purposefully selected to support students in developing a more meaningful understanding of the Particulate Nature of Matter (PNM) by connecting scientific concepts to everyday experiences. Traditional methods of teaching science often present content in an abstract, decontextualised

format that fails to engage students or make the content relatable. In contrast, the CBTA focuses on embedding concepts in real-life situations, making learning more student-centred, interactive, and practical.

The use of the context-based approach in this study was rooted in the constructivist theory of learning, particularly Vygotsky's social constructivism. The approach assumes that students learn best when they are able to relate new information to what they already know, and when instruction is situated within familiar environments. This was particularly relevant to students at Mozano College of Music SHS, where the diversity in learning needs and backgrounds required a flexible, inclusive teaching strategy. By situating scientific knowledge in local and familiar contexts, students were able to bridge the gap between theoretical chemistry and practical understanding.

The intervention was designed and delivered following a three-phase instructional sequence:

Contextualisation: Lessons began with real-life scenarios that students could easily relate to. Examples included boiling water, the melting of ice, dissolving salt in water, or the steam rising from cooking rice. These scenarios served as entry points for introducing the scientific content in a way that piqued interest and curiosity.

Concept Introduction: After the context was established, the underlying scientific concepts were explored. Students were guided to identify the particle-level explanations for what was happening in the scenarios, such as particle motion during heating, or the arrangement of particles in solids, liquids, and gases.

Application and Reflection: Students then engaged in group discussions, exercises, and written tasks that required them to apply the concepts learned back to the context

presented, or to other similar everyday situations. This stage reinforced learning through peer collaboration and problem-solving.

In all, six lessons were delivered over a structured period. Each lesson integrated teacher explanations with student-centred tasks. Students worked in pairs and small groups to encourage interaction and active participation, which are essential features of context-based instruction. The approach was not just about using local examples, but also about creating opportunities for students to engage with content meaningfully, ask questions, explain phenomena in their own words, and apply knowledge to new situations.

Details of the lesson plans are as follows;

Week 1: Introduction to States of Matter and Their Characteristics

Lesson Objectives By the end of this lesson, students were expected to:

1. Describe the characteristics of solids, liquids, and gases in terms of particle arrangement, movement, and energy.
2. Explain how particle size and spacing vary in different states of matter.
3. Provide real-life examples of solids, liquids, and gases.

Materials Used

- Everyday objects (ice, water, air-filled balloon)
- Whiteboard and markers
- Worksheets and handouts
- Video clips demonstrating particle behaviour in different states

Lesson Structure

Introduction (10 minutes)

1. **Set Induction:** The lesson began by displaying everyday objects like an ice cube, a glass of water, and an air-filled balloon. I asked students to observe these objects and discuss their physical states. *To create a context-based learning scenario, I linked these objects to students' daily experiences, such as noticing that ice melts in a drink or observing water in different forms at home.* This approach helped students immediately relate to the lesson content.
2. **Trigger Questions:** I asked, *“Think about the last time you saw ice melting in a drink or noticed steam rising from boiling water. What do you think is happening to the particles in these materials?”* These questions were designed to connect students' prior experiences with the scientific concepts they were about to learn, making the abstract idea of particle movement more tangible.

Main Teaching Activities (30 minutes)

1. **Direct Instruction (10 minutes):**
 - I introduced the three states of matter solids, liquids, and gases using the whiteboard to highlight key terms such as "particle arrangement," "movement," and "energy."
 - I used the ice cube to represent solids (tightly packed particles), water to represent liquids (loosely packed particles with moderate movement), and the balloon to represent gases (widely spaced particles with rapid movement). *To reinforce the context-based approach, I asked students to imagine how the tight packing of particles in ice explains why it stays solid in a freezer, and how the loose arrangement of particles in water*

allows it to flow freely, as they would see when pouring water into a glass.

2. Hands-On Activity (10 minutes):

- **Activity Description:** Students were divided into small groups and given the objects used in the introduction. Each group observed the objects and discussed their properties, such as texture, shape, and volume. They then classified the objects as solids, liquids, or gases based on these observations.
- *During this activity, I guided students to think about how the state of each object influences its use in daily life. For example, we discussed how the solid state of ice is ideal for cooling drinks, how the liquid state of water is essential for drinking and cooking, and how the gaseous state of air allows balloons to float. This real-life context helped students understand why the physical state of a substance matters in practical terms.*

3. Video Presentation and Group Discussion (10 minutes):

- **Video:** A video clip was shown that visually demonstrated the behaviour of particles in solids, liquids, and gases. The video emphasized differences in particle spacing and movement, reinforcing the concepts discussed earlier.
- **Discussion:** After the video, students engaged in a group discussion. *I prompted them to relate the video content to familiar scenarios, such as why ice cream stays solid in the freezer but melts on a hot day, or why balloons filled with air can expand and float. These context-based scenarios made the lesson more relevant and meaningful.*

Closure (10 minutes)

1. **Reflection:** Students wrote down one new thing they learned about the states of matter on a sticky note and placed it on the board as they left the class. *They were encouraged to think of real-life examples that fit into what they had learned, such as noticing how water behaves when poured from one container to another.* This reflection activity helped solidify the connection between the lesson content and everyday experiences.

Week 2: Applications of the Three States of Matter

Lesson Objectives By the end of this lesson, students were expected to:

1. Identify and explain the applications of solids, liquids, and gases in various contexts.
2. Understand the importance of different states of matter in daily life and industry.
3. Relate the properties of states of matter to their uses in real-world applications.

Materials Used

- Case studies on the industrial applications of states of matter
- Objects representing different states of matter (e.g., metal, water, helium balloon)
- Whiteboard and markers
- Worksheets and handouts

Lesson Structure

Introduction (10 minutes)

1. **Recap of Previous Lesson:** The lesson began with a brief recap of the previous lesson, where students were asked to recall the characteristics of solids, liquids, and gases. This helped to reinforce their understanding and provided a foundation for the new lesson.
2. **Motivational Set:** I introduced the topic by discussing how different materials are used in everyday life, such as metal for building materials, water in cooking, and helium in balloons. *I used these examples to create context-based scenarios: for instance, discussing how the solid state of metal allows it to support heavy structures like bridges, or how helium gas in balloons makes them float at birthday parties.* This approach helped students see the relevance of states of matter in their own lives.

Main Teaching Activities (35 minutes)

1. **Direct Instruction (10 minutes):**
 - **Explanation:** I explained how the properties of solids, liquids, and gases determine their applications in various industries. For example, I discussed how the hardness of metals makes them ideal for construction, while the fluidity of liquids is essential in processes like cooking and cleaning.
 - *To emphasize the context-based approach, I asked students to think about how different states of matter are essential in industries they might be familiar with such as how the liquid state of water is crucial in the*

food industry for mixing and dissolving ingredients, or how the solid state of bricks makes them perfect for building houses. These examples were chosen to make the lesson content more relevant to the students' everyday experiences.

2. Case Study Analysis (15 minutes):

- **Group Activity:** Students were divided into groups and given case studies that highlighted the application of different states of matter in industries such as food processing, healthcare, and construction. Each case study was designed to show how the specific properties of a state of matter make it suitable for certain uses.
- **Presentation and Discussion:** After analysing the case studies, each group presented their findings. *For instance, one group discussed how the liquid state of water is vital in food processing, where it is used in cooking and cleaning, while another group explored how the solid state of metals makes them indispensable in the construction industry. These context-based discussions helped students understand the practical importance of states of matter in various fields.*

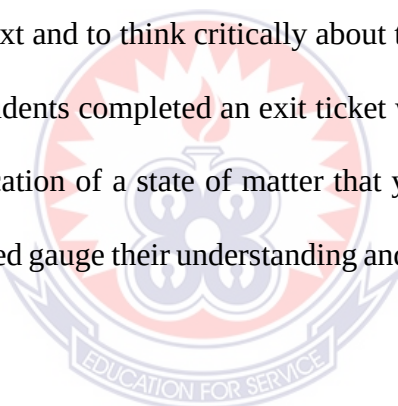
3. Application Activity (10 minutes):

- **Matching Exercise:** Students were provided with a worksheet that included various objects and their industrial applications. They matched each object to its correct application based on its state of matter. *For example, they matched the solid state of metal with construction, the liquid state of oil with lubrication in machines, and the gaseous state of helium with filling balloons.*

- **Class Review:** The answers were reviewed as a class, and I provided additional explanations where necessary, reinforcing the importance of understanding the properties of matter in different contexts.

Closure (5 minutes)

1. **Homework Assignment:** Students were assigned to investigate and write a short report on how the states of matter are used in a specific industry or context of their choice. *For example, they could explore how the solid state of glass is used in making windows or how the liquid state of paint is essential for coating surfaces.* This assignment encouraged them to apply what they had learned in a real-world context and to think critically about the materials around them.
2. **Exit Ticket:** Students completed an exit ticket with the question, "What is one important application of a state of matter that you learned today?" This quick assessment helped gauge their understanding and provided feedback for the next lesson.



Week 3: Behaviour of the States of Matter

Lesson Objectives By the end of this lesson, students were expected to:

1. Explain how temperature affects the movement and behaviour of particles in solids, liquids, and gases.
2. Describe phase changes and the conditions under which they occur.
3. Relate the behaviour of states of matter to everyday phenomena and technological applications.

Materials Used

- Everyday objects to demonstrate phase changes (e.g., ice, boiling water)
- Videos showing phase changes and particle behaviour
- Thermometer, heat source (e.g., Bunsen burner), beakers
- Worksheets and handouts

Lesson Structure

Introduction (10 minutes)

1. **Observational Question:** The lesson began by asking students to describe what happens when they leave an ice cube out on a warm day. I followed up with, *“Why do you think ice melts on a hot day and water turns into steam when boiled? What does this tell us about how particles behave when they gain heat?”* This activity encouraged students to draw on their prior knowledge and set the stage for exploring phase changes.
2. **Objective Setting:** I outlined the lesson’s objectives on the board, emphasizing that understanding phase changes and particle behaviour is crucial in both everyday life and technology.

Main Teaching Activities (35 minutes)

1. **Demonstration (10 minutes):**
 - **Phase Change Demonstration:** I performed a live demonstration of phase changes using ice, water, and a heat source. Students observed as the ice melted into water and the water boiled into steam. I used a thermometer to measure the temperature at each stage, explaining how

the energy absorbed by the particles caused them to move faster and change states.

- *During the demonstration, I connected the lesson to real-life scenarios by asking students to think about everyday situations where they see these changes, such as ice melting in a drink or water boiling on a stove. This helped them understand that the science behind these changes is something they observe regularly.*

2. Video Analysis (10 minutes):

- **Watch Video:** A video was shown that depicted the molecular changes during phase transitions (solid to liquid to gas). The visual representation helped students grasp the concept of particle movement during these changes.
- **Think-Pair-Share:** After the video, students paired up to discuss what they observed. *They were asked to explain the process of melting and boiling at the particle level, relating it to situations they encounter, such as why a cold drink gets watered down as the ice melts, or how steam rises from a kettle when it's boiling.* This context-based discussion reinforced their understanding of phase changes in a familiar context.

3. Group Activity (15 minutes):

- **Temperature and Particle Movement:** Students were given a worksheet with different scenarios where temperature affects the state of matter, such as refrigerating water to make ice or heating metal until it melts. Each group discussed how particle movement changes with temperature and presented their findings.

- *To make the lesson more context-based, I asked them to think about technological applications they know of, such as how refrigeration is used to preserve food by slowing down particle movement or how heating is used in manufacturing to melt metals for moulding. These discussions highlighted the relevance of phase changes in everyday life and industry.*

Closure (5 minutes)

1. **Reflection:** Students wrote a short paragraph on *how understanding phase changes is important in everyday life and technological applications, such as why ice is used in cooling systems or how steam is used to power engines. This reflection allowed them to consider the practical implications of what they had learned.*

Week 4: Particles of Matter: Atoms, Molecules, and Ions

Lesson Objectives By the end of this lesson, students were expected to:

1. Define and differentiate between atoms, molecules, and ions.
2. Explain how atoms combine to form molecules and how ions are formed.
3. Relate the concepts of atoms, molecules, and ions to everyday examples and chemical reactions.

Materials Used

- Molecular model kits
- Whiteboard and markers
- Videos illustrating atomic and molecular structures

- Worksheets and handouts

Lesson Structure

Introduction (10 minutes)

1. **Brainstorming Session:** The lesson began with a brainstorming session where students were asked to list substances they encounter daily, such as water and salt. I wrote their responses on the board to visually connect the lesson to familiar items.
2. **Introduction to Concepts:** I introduced the terms "atoms," "molecules," and "ions," explaining that these are the fundamental building blocks of matter. *To make the concepts relatable, I used the example of water (H_2O), a substance all students are familiar with, to explain how two hydrogen atoms combine with one oxygen atom to form a water molecule. I also used the example of table salt ($NaCl$) to explain how sodium (Na) and chloride (Cl) ions combine to form the compound they use every day in their food.*

Main Teaching Activities (35 minutes)

1. **Direct Instruction (10 minutes):**
 - **Explanation:** I defined atoms, molecules, and ions, using simple diagrams on the whiteboard to illustrate how atoms combine to form molecules (e.g., H_2O) and how ions are formed (e.g., Na^+ and Cl^- in table salt). *I emphasized the real-world relevance by asking students to think about how these particles make up everything they see around them from the water they drink to the food they eat.*

- **Contextual Examples:** I used molecular model kits to construct simple models of common molecules and ions, such as water (H_2O) and sodium chloride (NaCl). *Students were encouraged to think about how these particles behave in different substances they encounter daily, such as why sugar ($\text{C}_6\text{H}_{12}\text{O}_6$) dissolves in water or how salt preserves food.*

2. **Hands-On Activity (15 minutes):**

- **Molecule Building:** Students worked in pairs using the molecular model kits to build models of water, carbon dioxide (CO_2), and sodium chloride. They were encouraged to explore different combinations and discuss how atoms interact to form molecules and ions.
- *During the activity, I guided students to think about the real-world implications of these molecules. For example, we discussed how CO_2 is a gas we exhale and how it is also responsible for the fizz in carbonated drinks. We also explored how NaCl is used not just in cooking, but also in processes like de-icing roads in cold climates. These examples helped students see the practical applications of the abstract concepts they were learning.*

3. **Video Analysis (10 minutes):**

- **Watch Video:** A video was shown that explained atomic and molecular structures, reinforcing the concepts discussed earlier. The video provided a detailed visual representation that helped solidify students' understanding.
- **Guided Discussion:** After the video, a guided discussion was held. *Students were asked to connect what they learned to real-life examples, such as how atoms form the oxygen (O_2) we breathe or how ions in salt*

help regulate our body's fluid balance. This discussion helped students understand the significance of atoms and molecules in their daily lives.

Closure (5 minutes)

1. **Class Discussion:** The lesson ended with a class discussion where students reviewed the key concepts. *They were encouraged to summarize what they learned about atoms, molecules, and ions, relating these concepts to substances they encounter regularly, like the carbon dioxide in soft drinks or the sugar in their tea.* This discussion reinforced the lesson's objectives and helped students see the relevance of chemistry in their everyday lives.

3.8.4 Post-intervention Activities

Following the four-week intervention, post-tests were administered to the students. Upon completion, the scripts were collected and scored to compile data for the post-intervention analysis.

3.8.4.1 Interview Data Collection Procedure

To gather qualitative data on students' perceptions of the context-based teaching approach, semi-structured interviews were conducted with a selected number of students. The interviews were held in the school library at Mozano College of Music Senior High School, a quiet and neutral environment that provided comfort and reduced distractions, ensuring that students could express themselves freely and honestly.

Each student was interviewed individually, and interviews were conducted in English to maintain consistency in interpretation. The interviewer used a semi-structured interview guide, which included open-ended questions aligned with the fourth research

question. The guide allowed flexibility for follow-up questions based on students' responses.

The interviews were audio-recorded using a mobile recording device, with prior informed consent obtained from all participants. To enhance trustworthiness, students were assured of confidentiality, anonymity, and that there were no right or wrong answers. This was intended to reduce social desirability bias and encourage authentic responses.

After each session, the audio recordings were transcribed verbatim within 24 hours. A second trained research assistant independently reviewed the transcripts for accuracy. To ensure the credibility and reliability of the responses, the Guba and Lincoln (1985) framework was employed, focusing on:

- Credibility: By using member checking, some students were invited to review their transcripts and confirm that their views had been accurately captured.
- Dependability: A consistent procedure was followed for all interviews.
- Confirmability: Field notes and reflective memos were maintained to document non-verbal cues and reduce researcher bias.
- Transferability: Thick descriptions of the setting and process were recorded to allow others to assess applicability to similar contexts.

Through these steps, the quality and reliability of the interview data were ensured, supporting the robustness of the qualitative findings of the study.

3.9 Data Analysis Procedure

Following data collection, statistical analysis was conducted utilising various tools and methods. SPSS (Statistical Package for the Social Sciences) version 25 and Microsoft Excel 2019 were employed as statistical software to facilitate analysis. Statistical techniques, including the paired t-test, were utilised to ascertain the presence of a significant difference between students' scores on the pre- and post-intervention tests. Descriptive statistics were employed where necessary to elucidate the characteristics of the data. Qualitative data from interviews underwent thematic analysis to identify recurring themes.

3.10 Ethical Considerations

A formal introductory letter, secured from the Department of Integrated Science Education, was dispatched to Mozano College of Music Senior High School, seeking permission to conduct the study. Upon receiving approval, the researcher took deliberate steps to ensure ethical standards were upheld throughout the data collection process.

To begin, the researcher diligently informed the students about the study's objectives, explaining the purpose and significance of the research. During this briefing, students were made aware of their rights as participants. The researcher also emphasised the importance of informed consent, ensuring that each participant understood the nature of their involvement before agreeing to take part in the study.

In addition to securing informed consent, the researcher made a commitment to maintaining confidentiality and anonymity. This was achieved by ensuring that all data collected, including test results and interview responses, were handled with strict confidentiality. Participants' identities were protected by assigning codes instead of

using their real names, thus ensuring anonymity in the reporting and analysis of the findings.



CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the results, analyses and findings aimed at investigating students' existing conceptions in the particulate nature of matter. It also includes results and discussions on the academic performance of students both before and after the implementation of context-based teaching approach in teaching and learning of particulate nature of matter, as well as students' perceptions of this teaching approach.

The data analysed to address the formulated research questions are presented in the same sequence as the research questions.

4.1 Quantitative Data Analysis

4.1.1 Research Question 1: *What are Students' Existing Conception about the Particulate Nature of Matter?*

Before the intervention, a Diagnostic Assessment was administered to all 37 students to probe their conceptions regarding the particulate nature of matter (PNM). The test consisted of five open-ended questions relating to different aspects of PNM. Each student's written response was analysed and categorised into:

Correct Conception (CC): Response aligned with scientifically accepted explanations.

Partial Conception (PC): Response included some correct ideas but also contained gaps or minor inconsistencies.

Alternative Conception (AC): Response showed a clear misunderstanding or misconception inconsistent with scientifically accepted explanations.

No Response (NR): Student either left the item blank or explicitly stated they did not know.

Table 1 displays the frequency (f) and percentage (%) of students (N = 37) in each category for five key concepts tested. Illustrative excerpts from students' written answers are provided to clarify how coding decisions were made.

Table 1: Students Conceptions about Key Aspects of the Particulate Nature of Matter.

Concept Tested	Sample Student Excerpt Illustrating "Correct Conception"	CC f (%)	PC f (%)	AC f (%)	NR f (%)
1. Characteristics of solids, liquids, and gases (particle arrangement & movement)	"In solids, the particles are packed so they just vibrate; in liquids, they slide past each other; in gases, they move freely."	7 (18.9)	18 (48.7)	5 (13.5)	7 (18.9)
2. Effect of temperature on particle movement	"When temperature rises, particles move faster and spread out; when it drops, they slow down."	5 (13.5)	9 (24.3)	3 (8.1)	20 (54.1)
3. Definition of an atom	"An atom is the smallest part of an element that can take part in a chemical reaction."	11 (29.7)	16 (43.3)	2 (5.4)	8 (21.6)
4. Formation of molecules from atoms	"A molecule forms when two or more atoms join by bonds, like H_2O is made of hydrogen and oxygen atoms bonded."	4 (10.8)	12 (32.4)	5 (13.5)	16 (43.3)
5. Formation of ions	"Ions are charged particles formed when atoms lose or gain electrons, like Na^+ ."	15 (40.6)	5 (13.5)	3 (8.1)	14 (37.8)

Field Data (2024).

CC = Correct Conception; PC = Partial Conception; AC = Alternative Conception; NR = No Response.

Percentages may not total exactly 100% per row due to rounding.

N = 37 students.

The following section provides detailed analysis and specific examples corresponding to the statistical distribution presented in Table 1, outlining students' existing conceptions about the particulate nature of matter.

Findings

The following findings are students' prior conceptions of the particulate nature of matter:

Concept 1 (States of Matter): Although 18.9% of students offered correct explanations, nearly half gave partially correct answers (48.7%), indicating some foundational but incomplete understanding of particle arrangement.

Concept 2 (Temperature & Particle Movement): Over half of the class (54.1%) did not respond or stated they were unsure. This suggests temperature's effect on particles was one of the least-understood aspects.

Concept 3 (Atoms): Nearly 30% accurately defined an atom, whereas 43.3% had partial definitions often omitting details about chemical reactivity or atomic structure.

Concept 4 (Molecules): Fewer than 11% fully understood how molecules form. A large portion (43.3%) left this question blank, suggesting a significant gap regarding bonding.

Concept 5 (Ions): This had the highest Correct Conception rate (40.6%), likely due to prior familiarity with charged particles. However, 37.8% still did not attempt this question.

These findings indicated that students generally had partial conceptions or alternative conceptions about crucial aspects of the particulate nature of matter, underscoring the need for an instructional intervention namely, the Context-Based Teaching Approach.

Discussion

The analysis of students' responses to the pre-intervention test revealed varied levels of understanding concerning the particulate nature of matter. Their responses were categorised into four conception levels: correct, partial, alternative, and no response. Table 1 presents the percentage distribution across these categories, which is elaborated below.

With regard to the characteristics of solids, liquids, and gases in terms of particle arrangement and movement, only 18.9% of students demonstrated a scientifically accurate conception. These students correctly described solids as having tightly packed particles that vibrate in place, liquids as having particles that are close together but free to slide past one another, and gases as comprising particles that move rapidly in all directions due to the wide spacing between them. For instance, one student stated, *“Solids have tightly packed particles that vibrate in place; liquids have particles that can move past each other; and gas particles are far apart and move in all directions.”* This reflects an understanding of all three states at the microscopic level, consistent with the kinetic particle theory. However, the majority of students (48.7%) exhibited partial conception. Their responses typically included one or two correct ideas, but with minor inconsistencies. For example, one student wrote, *“Liquid particles are close together but some are fixed like in solids,”* blending characteristics from different states. Others showed confusion about the distribution of gas particles, suggesting that gases are not evenly spread. About 13.5% held alternative conceptions, such as *“Gas particles stay still in the container”* or *“Solids have particles that move around freely,”*

both of which indicate fundamental misunderstandings. These misconceptions mirror findings by Boz (2006), who observed that many students believed solids were completely immobile and gases behaved like liquids. A notable 18.9% of students gave no response, which could reflect a lack of prior exposure to particle theory, low confidence, or unfamiliarity with the concept, as noted in studies by Riaz (2004) and Mishra and Kumar (2023).

On the effect of temperature on particle movement, only 13.5% of students demonstrated correct understanding. These students clearly stated that heating causes solid particles to vibrate more vigorously, increases the speed of particles in liquids, and causes gas particles to move faster and expand. One student accurately wrote, *“When a solid is heated, the particles vibrate more. In liquids, the particles move faster and may turn into gas. Heating gases makes the particles spread out more.”* A further 24.3% demonstrated partial understanding, with explanations like *“Heating turns everything into liquid,”* which oversimplifies the process of phase change. Some also believed that gases are unaffected by temperature changes, indicating a limited understanding of kinetic energy. Students in this category understood that heating affects movement, but failed to apply this across all states. Approximately 8.1% of students held alternative conceptions, with statements such as *“Heating makes solid particles move slower”* or *“Gas particles stay the same when heated.”* These reflect a clear reversal or rejection of scientific principles. According to Malhotra (2020), such misconceptions are common, especially regarding how temperature affects density and expansion in matter. Notably, 54.1% of students did not respond to this question, suggesting the abstract nature of the topic and possible teaching gaps, as previously noted by Riaz (2004).

In terms of the definition of an atom, 29.7% of students provided accurate responses, describing the atom as the smallest unit of matter composed of protons, neutrons, and electrons. One student explained, *“An atom has a nucleus with protons and neutrons, and electrons orbit around it,”* showing good conceptual understanding. However, 43.3% had partial understanding, often referring to atoms as “tiny particles” or “the smallest part of matter,” without elaborating on internal structure. Although not incorrect, these responses lacked detail. Only 5.4% held alternative conceptions, including statements like *“An atom is a small molecule,”* or *“Atoms only have protons,”* reflecting significant confusion. According to research by Nakiboglu (2003), such misconceptions are common, often because students confuse atoms with other microscopic structures like cells or molecules. A further 21.6% gave no response, which again points to either cognitive difficulty or insufficient exposure to atomic models.

When asked about the formation of molecules from atoms, only 10.8% of students gave fully accurate answers, describing the process as atoms sharing or transferring electrons to form chemical bonds. For instance, a correct response stated, *“Atoms form molecules through covalent or ionic bonds by sharing or giving electrons.”* Meanwhile, 32.4% of students demonstrated partial understanding, suggesting molecules form when “atoms come close together” or “stick together,” indicating awareness of interaction but lacking clarity about bonding types. Approximately 13.5% held alternative conceptions, such as *“Atoms form molecules by mixing”* or *“Atoms join by merging their centres,”* which confuse physical mixing with chemical bonding. These types of misconceptions were also found in Oztuna et al.’s (2013) study, where students believed bonding involved concrete connectors between atoms. A total of 43.3% of students gave no response, revealing limited prior knowledge or lack of confidence in addressing the concept.

Finally, regarding the formation of ions, 40.6% of students correctly explained that ions are formed when atoms gain or lose electrons, thus acquiring a charge. One student wrote, *“Atoms become ions by gaining electrons to become negative, or losing electrons to become positive,”* showing a clear understanding. About 13.5% displayed partial understanding, often stating that *“Atoms become ions when they react,”* without specifying the electron transfer process. Another added, *“Ions are formed during chemical reactions,”* which is true but vague. In contrast, 8.1% held alternative conceptions, such as *“Atoms become ions by gaining or losing protons,”* which reflects a misunderstanding of atomic structure. Some even wrote *“Ions are atoms with extra protons,”* showing deep-rooted confusion. A significant 37.8% provided no response, reinforcing the complexity of the topic and the need for more context-based instruction and modelling.

In summary, the analysis of students’ existing conceptions showed that many held partial or alternative views, particularly regarding dynamic particle behaviour and bonding processes. While atomic structure and ion formation were more accurately understood, concepts like temperature effects and molecule formation showed high levels of conceptual gaps. These findings strongly supported the relevance of a context-based teaching approach in bridging the gap between theory and practical understanding, especially in abstract topics like the particulate nature of matter.

4.1.2 Research Question 2: What is the academic performance of students before and after the use of context-based approach in teaching and learning of the particulate nature of matter?

Table 2 presents the frequency distribution of students’ performance in the pre-test and post-test. The scores were grouped into six ranges, and frequencies and percentages

were calculated to illustrate the overall performance trend before and after the intervention. The raw data of students' scores can be found in appendix I.

Table 2: Frequency Distribution of Students' Pre-Test and Post-Test Scores on the Particulate Nature of Matter

Score Range (out of 20)	Pre-Test Frequency	Pre-Test %	Post-Test Frequency	Post-Test %
0–4	2	5.4%	0	0.0%
5–7	14	37.8%	3	8.1%
8–10	14	37.8%	9	24.3%
11–13	5	13.5%	15	40.5%
14–16	2	5.4%	9	24.3%
17–20	0	0.0%	1	2.7%
Total	37	100%	37	100%

Source: Field Data (2024)

Paired Samples t-Test Results

To statistically determine whether the observed improvement in performance was significant, a paired samples t-test was conducted. This test compared students' mean pre-test scores ($M = 7.43$, $SD = 2.43$) and post-test scores ($M = 12.24$, $SD = 2.07$). The results are presented in Table 3.

Table 3: Paired Samples t-Test Results Comparing Pre-Test and Post-Test Scores

Tests	Class size	Mean	Mean Diff.	Standard Deviation	p-value	Remarks
Pre- test	37	7.43	4.81	2.43	0000	Significant
Post- test	37	12.24		2.07		

Source: Field Data (2024)

The p-value (0.000) is less than the 0.05 significance level, indicating a statistically significant difference between students' pre-test and post-test scores. This suggests that

the context-based teaching approach had a positive effect on students' academic performance in the topic of the particulate nature of matter.

Findings

The results from the frequency distribution and paired samples t-test revealed a marked improvement in students' academic performance after the implementation of the context-based teaching approach. Before the intervention, the majority of students (75.6%) scored between 5 and 10 marks, with only a small percentage (13.5%) achieving scores above 10. After the intervention, the performance shifted significantly, with 67.5% of students scoring 11 marks or higher and no student scoring below 5 marks. This clearly demonstrates a general improvement in the academic performance of the students.

The paired samples t-test further confirmed the effectiveness of the intervention. The increase in the mean score from 7.43 in the pre-test to 12.24 in the post-test was statistically significant (The p-value (0.000) is less than the 0.05 significance level). This indicates that the improvement in performance was not due to chance, but can be attributed to the application of the context-based teaching approach. The relatively lower standard deviation in the post-test ($SD = 2.07$) also suggests more consistent performance among students, further highlighting the positive impact of the teaching method.

Discussion

The frequency distribution of students' scores before and after the intervention shows a clear shift in performance levels. In the pre-test, the majority of students (75.6%) scored between 5 and 10 marks, and only 13.5% scored above 10. Two students scored between 0 and 4, indicating significant gaps in understanding. However, after the use

of the context-based teaching approach, no student scored below 5, and 67.5% scored 11 or more marks. A small number of students (24.3%) even scored between 14 and 16 marks, and one student reached the 17–20-mark range.

This upward shift in the frequency of high scores shows that students' understanding of the topic *Particulate Nature of Matter* improved across all performance bands. More students moved from the lower score ranges to the middle and higher ranges. This suggests that the intervention was effective not only in helping students perform better but also in reducing the number of students with weak understanding.

In addition to the frequency distribution, the paired samples t-test provided a statistical confirmation of the performance improvement. The mean score increased from 7.43 in the pre-test to 12.24 in the post-test. The test results showed that the difference was statistically significant at $p < 0.05$. This indicates that the observed improvement was not by chance but as a result of the context-based teaching approach.

These results show that teaching science through real-life examples and familiar situations helps students better understand difficult concepts like the particulate nature of matter. Many students struggle to understand this topic because they cannot see particles with the naked eye. Concepts like movement of particles, formation of molecules, or effect of temperature on matter are usually taught through diagrams and definitions. However, when such content is connected to everyday experiences like boiling water, dissolving sugar, or keeping drinks cold with ice, students are able to visualise and explain what happens at the particle level.

This improvement reflects the key ideas of Vygotsky's Constructivist Theory, which states that learners make meaning by connecting new knowledge to what they already know. Vygotsky explained that learning happens best when students are supported

within their zone of proximal development that is, when teachers introduce new ideas that are just above the learner's current level but can be understood through guidance and familiar experiences. In this study, the context-based approach served as that bridge. Students were able to relate science to their daily lives, making the content easier to understand and apply.

These findings are supported by previous studies that used similar approaches. Agyei (2020) found that students taught with a context-based method showed better academic performance and greater interest in genetics. Ahmed (2017) also reported significant improvement in chemistry scores when Nigerian students were taught hydrocarbons using real-life situations. These studies confirm that context-based teaching is a useful tool in helping students understand abstract science topics.

Moreover, the decrease in the standard deviation in post-test scores suggests that performance became more consistent. This implies that even students who previously performed poorly were able to catch up and perform better, reducing the gap between low and high achievers. This is an important outcome because it shows that context-based teaching does not only benefit high-performing students but supports all learners.

The results of the study clearly show that the context-based teaching approach led to improved student performance in the topic *Particulate Nature of Matter*. The shift in score frequencies and the significant results from the t-test both confirm the positive effect of the approach. By helping students relate science to real-life experiences, the method promoted better understanding and made learning more meaningful.

4.1.3 Research Question 3: What is the academic performance of male and female students before and after the implementation of a context-based teaching approach?

This section presents the academic performance of male and female students in the *Particulate Nature of Matter* before and after the use of the context-based teaching approach. The comparison is based on their scores in both the pre-test and post-test. An independent samples t-test was conducted to determine whether any significant differences existed between the two groups at each stage.

In the tables below, “N” refers to the number of students in each gender group who participated in the test at the time of data collection.

Pre-Test Performance by Gender

The results presented in table 4 shows the academic performance of male and female students prior to the implementation of the context-based teaching approach.

Table 4: Independent Samples t-Test Results for Male and Female Students Before Intervention

Gender	N	Mean Score	Mean Difference	p-Value	Remarks
Male	25	7.85	0.84	0.185	Not significant
Female	12	7.01			

Source: Field Data (2024)

Post-Test Performance by Gender

The results presented in table 5 below displays the post-test results following the implementation of the context-based teaching approach.

Table 5: Independent Samples t-Test Results for Male and Female Students After Intervention

Gender	N	Mean Score	Mean Difference	p-Value	Remarks
Male	25	12.53			
Female	12	11.95	0.58	0.191	Not significant

Source: Field Data (2024)

Findings

The analysis of pre-test scores showed that male students had a mean of 7.85 while female students had a mean of 7.01. The mean difference of 0.84 was not statistically significant ($p = 0.185$), indicating that both groups started the intervention with similar levels of understanding of the *Particulate Nature of Matter*.

After the implementation of the context-based teaching approach, both groups showed improvement. Male students recorded a post-test mean of 12.53, while female students had a mean of 11.95. The mean difference of 0.58 was again not statistically significant ($p = 0.191$), suggesting that the academic gains from the intervention were comparable between males and females.

Discussion

The results of this study show that there was no meaningful difference in the academic performance of male and female students, both before and after the implementation of the context-based teaching approach. Although male students recorded slightly higher mean scores than females in both the pre-test and post-test, the differences were small and not statistically significant. This suggests that the learning gains observed after the intervention were not dependent on gender.

The outcome of this study reflects the inclusive nature of the context-based teaching approach. By using everyday examples, relatable situations, and practical experiences familiar to students, the teaching method removed the kinds of classroom barriers that often lead to unequal participation or performance between boys and girls. Students were engaged with examples such as boiling water, cooking, dissolving solids in liquids, and the use of common household items all of which provided fair and equal learning opportunities, regardless of gender.

This finding is in line with the work of Barineka and Avwiri (2014), who also found no significant difference in the achievement of male and female students when a context-based teaching approach was used to teach inorganic chemistry. Their study concluded that using local examples and relatable content allowed both boys and girls to develop a better understanding of chemistry concepts. Similarly, Achor (2024) conducted a study on the use of a context-based strategy to teach physics and reported that there was no significant difference in academic achievement between male and female students exposed to the method. In both studies, the teaching strategy promoted equal learning gains for all students.

Both male and female students demonstrated improvement in understanding and applying the *Particulate Nature of Matter* after the intervention. This improvement, though slightly higher among males, was not significant enough to conclude that one gender benefited more than the other. Instead, the results confirm that context-based teaching supports balanced academic growth for learners regardless of gender.

4.2 Qualitative Data Analysis

The qualitative data were derived from semi-structured interviews conducted with six students after the context-based teaching intervention. The purpose of these interviews

was to gain insight into students' perceptions of the Context-Based Teaching Approach (CBTA) and its influence on their understanding of the particulate nature of matter.

A thematic analysis approach was used to analyse the interview transcripts. This involved coding the transcribed responses and identifying recurring ideas or perceptions that reflected the students' experiences. The Interview transcripts can be found in Appendix H.

4.2.1 Research Question 4: What are students' perceptions of context-based teaching approach in teaching and learning of particulate nature of matter?

This section presents the qualitative results of students' perceptions regarding the use of the context-based teaching approach in learning the *Particulate Nature of Matter*. Data was gathered through structured interviews with six students (coded as Students K, M, Q, H, E, and G). The interview transcripts were analysed thematically. Students were asked open-ended questions related to their understanding, engagement, collaboration, interest, and motivation following the intervention.

The results are organised under six emerging themes that reflect students' views on the impact of the context-based method on their learning experience.

Results

Theme 1: Enhanced Understanding and Application of the Particulate nature of matter

The context-based teaching approach appears to significantly improve students' comprehension of the particulate nature of matter by making it more relatable and practical. This theme explores how students perceive their understanding of the particulate nature of matter after being taught through real-life contexts.

The following are students' responses in support of context-based teaching in improving understanding and application of particulate nature of matter:

Student K:

I understand the particulate nature of matter much better now. The context-based teaching helped me see how it works in real-life situations.

Student K acknowledges a significant improvement in their understanding of the particulate nature of matter, attributing this progress to the context-based approach. By relating the concept to real-life scenarios, the abstract nature of the particulate nature of matter became more concrete and accessible, facilitating better comprehension.

Student M:

I feel more confident about the particulate nature of matter because the examples from real life made it easier to grasp.

Student M's increased confidence in the particulate nature of matter is directly linked to the real-life examples used in the context-based teaching. This approach made the theoretical concepts more understandable and less intimidating, thus boosting the student's self-assurance in their knowledge.

Student Q:

My understanding has improved significantly. Context-based teaching made the concept less abstract and more tangible.

Student M reflects a significant enhancement in their grasp of the particulate nature of matter, noting that the context-based method reduced its abstractness. By presenting the concept in practical terms, the teaching approach transformed theoretical knowledge into something more tangible and relatable.

Theme 2: Enhanced Critical Thinking and Problem-Solving Skills

The context-based teaching method fosters improved critical thinking and problem-solving abilities. This theme examines how the approach influenced students' cognitive skills in applying the particulate nature of matter to various problems. The following are students' responses in support of context-based teaching in enhancing critical thinking and problem-solving skills:

Student E:

It encouraged me to think more deeply about problems and find practical solutions, rather than just memorising formulas.

Student E highlights how the context-based approach prompted a deeper level of cognitive engagement. Instead of relying on rote memorization, the approach encouraged them to think critically and apply the particulate nature of matter to find practical solutions.

Student M:

It enhanced my problem-solving skills by making me think about how to use the particulate nature of matter in practical situations.

Student M experienced a boost in problem-solving skills due to the practical application of the particulate nature of matter. The context-based approach required them to apply theoretical knowledge to real-world problems, enhancing their ability to tackle complex issues.

Student H:

The context-based approach sharpened my critical thinking skills because I had to apply the concept to different scenarios.

Student H's critical thinking skills improved as they engaged with diverse scenarios where the particulate nature of matter was applied. This exposure to various contexts challenged them to think more analytically and creatively.

According to Haryanto & Arty (2019), one of the characteristics of the contextual methods is group work, discussion, and peer correction. Therefore, students discuss one another, have the responsibility for solving the problems, and share ideas for solutions if they work together in a group (Harmer, 2004).

Theme 3: Increased Collaboration and Interaction with Classmates

The context-based approach promotes greater collaboration and interaction among students, which can enhance the learning experience. This theme explores how students' interactions and teamwork were influenced by the new teaching method. The following responses from students endorsed increased collaboration and interaction with classmates during context-based lessons:

Student K:

We worked more as a team and helped each other understand the concepts better. It made the class more interactive and engaging.

Student K notes that the context-based approach fostered teamwork and collaborative learning. The interactive nature of the approach led to enhanced understanding through peer support and collective problem-solving.

Student Q:

It fostered more collaboration because we often had to work together to solve context-based problems.

Student Q emphasised that collaboration was a key component of the context-based teaching method. The necessity to work together on context-based problems strengthened peer interactions and collective learning.

Student H:

The context-based method improved our interactions. We discussed and debated different solutions to problems, which enhanced our learning.

Student H experienced improved classroom dynamics due to the context-based approach. The opportunity for discussion and debate over various solutions not only facilitated better understanding but also encouraged a more interactive learning environment

The results of the study coincide with the previous findings by Indrilla (2018; Satriani et al. (2012), and Rafida (2016). The CTL approach could make students actively involved in collaborating and socialising with others in order to solve problems.

Theme 4: Increased Motivation and Interest in Learning Chemistry

The context-based approach appears to enhance students' motivation and interest in chemistry by demonstrating the relevance of the material to real-life situations. This theme assesses how the teaching method affected students' enthusiasm for the subject. The following responses from students endorsed increased motivation and interest in learning chemistry during context-based lessons:

Student G:

My interest in chemistry has definitely increased because I see how it's used in real life.

Student G's increased interest in chemistry is attributed to the real-life applications presented through context-based teaching. Seeing the relevance of chemistry in everyday life has sparked a greater enthusiasm for the subject.

Student E:

I'm more motivated to learn chemistry now because the context-based approach makes it more interesting and relevant.

Student E's motivation to study chemistry has risen due to the engaging nature of context-based teaching. The approach made the subject matter more interesting and connected to real-world applications, thereby boosting motivation.

Student H:

It has made me more interested in chemistry because I can see its practical applications.

Student H's increased interest in chemistry is linked to the practical applications demonstrated through the context-based approach. Understanding how chemistry principles are applied in real-world contexts has made the subject more appealing.

The findings of this study coincide with those of Rayner (2005)'s study which revealed that context-based instruction has the potential to affect student outcomes; specifically, their interest, motivation and understanding of the subject, in a positive way.

Theme 5: Real-World Relevance and Practical Application

The context-based teaching approach significantly emphasised the practical application of theoretical concepts. This theme explored how students perceived the real-world relevance of the states of matter and their characteristics, as well as particles of matter

(atoms, molecules, and ions), after being taught through context-based approaches. The following responses from students endorsed real-world relevance and practical application of concepts during context-based lessons:

Student K:

"It has helped a lot. For example, I now understand why solids like ice are used to keep drinks cold because their particles are packed tightly together and don't move around much. This makes them effective for maintaining low temperatures."

Student K highlights the direct relevance of understanding the characteristics of solids, such as their tightly packed particles and fixed shape, in everyday contexts like keeping drinks cold with ice. This response shows that context-based teaching helps students relate abstract concepts to tangible, real-world applications, enhancing their comprehension and appreciation of the subject matter.

Student H:

"It showed me how temperature affects how particles move, which is useful for things like cooking. When we learned that gases expand when heated, it made sense why steam rises when boiling water."

Student H's response reflects the practical utility of understanding the behaviour of particles in different states of matter in everyday scenarios, such as cooking. This practical understanding indicates a deeper grasp of the subject matter, facilitated by context-based examples that make learning more relevant and engaging.

Student E:

"I can now relate the different states of matter to real-world problems, like making sure we mix the right amount of ingredients in a recipe. Knowing how solids dissolve in liquids and how gases can affect the mixture really helps in cooking."

Student E's ability to relate the behaviour of different states of matter to specific real-world problems, such as ensuring correct ingredient ratios in recipes, demonstrates the effectiveness of context-based teaching. This approach helps students apply theoretical knowledge to practical situations, making their learning experience more meaningful and applicable.

Student M:

"Learning about atoms, molecules, and ions showed me how reactions work in everyday products. For example, now I get why certain substances dissolve better in water because of how the molecules interact."

Student M's response indicates an understanding of the particles of matter and their practical applications in everyday scenarios, such as dissolving substances in water. This demonstrates that context-based teaching successfully bridges the gap between classroom learning and real-world applications, helping students see the relevance of what they learn.

Student E:

"Building molecular models helped me see how atoms combine to form molecules. It made it easier to understand why sugar dissolves in water but oil doesn't because of the different ways their molecules interact with water molecules."

Student E's response emphasizes the effectiveness of hands-on activities in helping students grasp abstract concepts and their practical applications. By visualizing and

manipulating molecular models, students can better understand the properties of different substances and how they interact with water, showcasing the value of interactive and context-based learning approaches.

Researchers have found that when chemistry is taught with students' daily real-life experiences and applications, students perform better (Broman et al., 2022; George et al., 2021). Context-based teaching is one of the ways of connecting chemistry to students' daily real-life experiences and applications (Podschatweit & Bernholt, 2018). In context-based teaching, scientific content is embedded in real-life situations that show students the application of scientific concepts and methods in real life (Aydin-Ceran, 2021; Taconis et al., 2016).

Theme 6: Recommendation of Context-Based Approach for Teaching Science Concepts

Based on student feedback and observed benefits, the context-based teaching approach demonstrates significant potential for enhancing the learning of science concepts. This theme delves into students' recommendations and the broader implications for adopting this method in teaching various science subjects. The following responses from students that recommended strong use of context-based teaching approach in science lessons:

Student Q:

I think using context-based teaching for other science topics would be really helpful. It makes complex ideas easier to understand when you can see how they apply to real life.

Student Q suggests that extending the context-based approach to other science topics could be beneficial. By making complex ideas more accessible through real-life

applications, students can achieve a deeper and more practical understanding of scientific concepts.

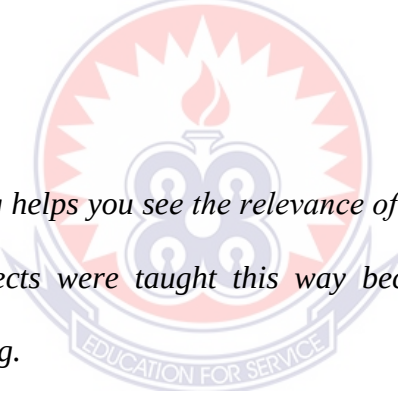
Student G:

This method should definitely be used for subjects like physics and biology too. It's a lot easier to remember concepts when you see how they work in everyday life.

Student G recommends the application of context-based teaching across various scientific disciplines, such as physics and biology. The enhanced memory retention resulting from seeing concepts in everyday contexts underscores the method's effectiveness in promoting lasting comprehension.

Student Q:

Context-based learning helps you see the relevance of what you're studying. It would be great if more subjects were taught this way because it makes learning more interesting and engaging.

The logo of the University of Education, Winneba, is a circular emblem. It features a central torch with a flame, set against a background of a stylized sunburst or starburst pattern. Below the torch, there is a banner with the text "EDUCATION FOR SERVICE". The entire emblem is encircled by a border.

Student Q advocates for broader adoption of context-based learning due to its ability to highlight the relevance of academic content. By making learning more interesting and engaging, this approach can potentially increase student motivation and interest in a wide range of subjects. Research works have (Mustafaoglu & Yucel 2022; Davis & Krajcik, 2005) recommended that context-based teaching be supported with appropriate learning materials in order to create positive effects on learning.

Findings

The interview results revealed that students had generally positive perceptions of the context-based teaching approach. They found the lessons more engaging, relatable, and

easier to understand. Students also demonstrated greater motivation, increased classroom interaction, and a clearer ability to apply concepts in real-life contexts. Importantly, they recommended that this teaching method be adopted for other science topics as well.

Discussion

The qualitative results confirm that the context-based teaching approach had a positive impact on students' experiences and attitudes toward learning chemistry. Students felt more confident and connected to the content when abstract ideas were taught using examples from their own environment. This made chemistry appear more practical, meaningful, and easier to retain.

The improved collaboration reported by students suggests that the approach fostered a more active classroom environment. Group discussions, shared problem-solving tasks, and real-world examples encouraged students to think beyond rote learning and engage with the material on a deeper level.

These findings are supported by Rayner (2005), who found that students who were taught using context-based strategies reported higher interest and improved understanding of scientific concepts. Similarly, Rafida (2016) noted that the use of contextual materials helped students relate better to chemistry topics and showed improved classroom participation.

The results indicate that context-based teaching is not only effective for improving academic performance (as seen in the earlier sections), but it also promotes positive student attitudes, which are essential for long-term learning and retention

CHAPTER FIVE

SUMMARY OF MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter presents the summary of the major findings of the study. It also presents the conclusions, recommendations and some suggestions needed for further research work.

5.1 Summary of Major Findings

The major findings of the study are summarised as follows:

1. The study found that many students had limited understanding of the particulate nature of matter before the intervention. Only 18.9% of students correctly described particle arrangement and movement in solids, liquids, and gases, while 48.7% showed partial understanding, 13.5% held alternative conceptions, and 18.9% provided no response. Similar trends were observed across related concepts such as the effect of temperature on particles, the structure of atoms, formation of molecules, and ions. These results, answering Research Question 1, highlight the widespread misconceptions students held before the context-based teaching approach was introduced.
2. With regard to Research Question 2 and Hypothesis 1, the findings showed a clear improvement in students' academic performance after the intervention. The mean score increased from 7.43 in the pre-test to 12.24 in the post-test. The difference was statistically significant, with a p-value well below the 0.05 threshold. This led to the rejection of the null hypothesis and confirmed that the context-based teaching approach contributed significantly to students'

academic gains in understanding the particulate nature of matter. The improvement also came with a reduction in score variability, showing more consistency in students' learning outcomes after the intervention.

3. In addressing Research Question 3 and Hypothesis 2, the study examined the performance of male and female students before and after the intervention. Before the teaching approach was introduced, males had a mean score of 7.85 and females had 7.01. After the intervention, the male mean score rose to 12.53 and the female mean to 11.95. Although male students consistently scored slightly higher than female students, the differences were not statistically significant ($p = 0.185$ before, $p = 0.191$ after). These findings suggest that both genders benefitted equally from the context-based teaching approach. Thus, the null hypothesis for gender difference was retained.
4. Finally, in response to Research Question 4, interview data revealed that students had overwhelmingly positive perceptions of the context-based teaching approach. Students reported improved understanding of abstract topics, greater confidence, increased motivation, and stronger engagement during lessons. They noted that the use of real-life examples helped make learning more practical and relevant. Many students also highlighted the collaborative nature of the lessons, and recommended that the context-based approach be adopted in other science areas as well. These perceptions support the quantitative findings and point to the effectiveness of the method not only in improving academic performance, but also in shaping a more engaging and inclusive learning experience.

5.2 Conclusion

The purpose of this study was to use the context-based teaching approach as a strategy to improve students' academic performance in the topic *Particulate Nature of Matter* (PNM). The study also sought to examine students' existing conceptions of the topic, determine if there were any differences in performance based on gender, and explore students' perceptions of the teaching approach.

The findings revealed that many students initially had weak or incomplete understanding of key concepts such as particle arrangement, temperature effects on particles, atomic structure, molecule and ion formation. Their pre-test results showed low average performance and high variability in responses, indicating the need for a more effective and engaging instructional method.

After the implementation of the context-based teaching approach, students' academic performance improved significantly. The average post-test scores increased meaningfully, and the statistical analysis showed that the improvement was significant. This confirms that the use of the context-based approach was effective in helping students better understand the concepts related to the particulate nature of matter.

The study also found no statistically significant difference in academic performance between male and female students, both before and after the intervention. This suggests that the teaching approach benefitted all students equally, regardless of gender.

In addition to academic improvement, students reported very positive perceptions of the context-based approach. They described the lessons as more engaging, easier to understand, and more connected to real-life experiences. Students also highlighted improvements in their critical thinking, motivation, and classroom participation.

In conclusion, the study has demonstrated that the context-based teaching approach is an effective strategy for improving students' academic performance and learning experiences in the *Particulate Nature of Matter*. It helped address conceptual difficulties, promoted inclusive learning, and enhanced student interest in chemistry. Based on these outcomes, the approach holds promise for wider use in science education in the Ghanaian senior high school setting.

5.3 Recommendations

Based on the findings of the study, the following recommendations were made:

1. Science teachers at Mozano College of Music should regularly conduct diagnostic assessments at the beginning of each unit to identify students' existing conceptions and misconceptions about key scientific concepts, especially abstract topics such as the particulate nature of matter. This will help guide lesson planning and instructional focus.
2. Context-based teaching strategies should be adopted consistently in the teaching of chemistry and other science subjects at Mozano College of Music. The study showed that this approach significantly improved students' academic performance and perception of science concepts.
3. Chemistry teachers should ensure that context-based activities are designed to be inclusive, allowing both male and female students to participate fully and benefit equally. This is crucial, as the study found no significant gender differences in performance after the intervention, suggesting that equitable access supports all learners.
4. Teachers should incorporate local and familiar examples into their lesson delivery. Examples from students' daily experiences such as cooking, cleaning,

or local weather changes help make abstract scientific ideas more concrete and relatable, thus increasing student motivation and engagement.

5. The Science Department at Mozano College of Music should organise peer-teaching sessions and lesson-study workshops to support teachers in developing and sharing effective context-based lesson plans. Collaborative lesson preparation can improve quality and ensure consistent application of the approach.

5.4 Suggestions for Further Studies

The researcher suggests that further studies be undertaken to investigate the effects of gender, motivational and affective factors in fostering conceptual change in the learning of the particulate nature of matter in senior high schools.

It is also recommended that future research expand the scope of the study by including a larger and more diverse sample drawn from multiple senior high schools across different regions to enhance the generalisability of findings related to the impact of context-based teaching on students' academic performance and perception.

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APPENDICE

APPENDIX A

Pre-Test

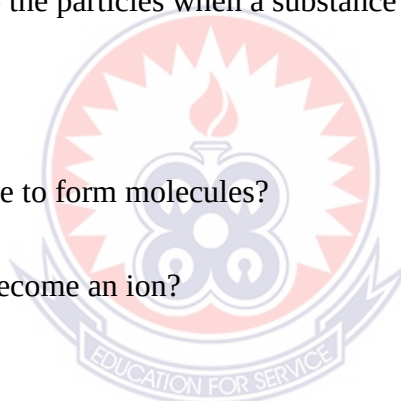
MOZANO COLLEGE OF MUSIC SENIOR HIGH SCHOOL

DURATION: 45 MINS

Answer all questions

1. Describe the characteristics of solids, liquids, and gases in terms of particle arrangement and movement.
2. Explain how temperature affects the movement of particles in solids, liquids, and gases. What happens to the particles when a substance is heated?
3. What is an atom?

How do atoms combine to form molecules?
5. How does an atom become an ion?



APPENDIX B

Answers to the Pre-Test (20 Marks)

1. Describe the characteristics of solids, liquids, and gases in terms of particle arrangement and movement.

Solids:

Particle Arrangement: Particles in a solid are closely packed together in a fixed, orderly arrangement.

Movement: Particles vibrate in place but do not move freely.

Liquids:

Particle Arrangement: Particles in a liquid are close together but not in a fixed position, allowing them to flow past one another.

Movement: Particles move more freely than in solids, enabling the liquid to take the shape of its container.

Gases:

Particle Arrangement: Particles in a gas are far apart and arranged randomly.

Movement: Particles move rapidly and freely, filling the entire volume of their container.

2. Explain how temperature affects the movement of particles in solids, liquids, and gases. What happens to the particles when a substance is heated?

Solids: When heated, the particles in a solid vibrate more vigorously, increasing in kinetic energy. If enough energy is provided, the solid may melt into a liquid.

Liquids: When heated, the particles in a liquid move faster and spread apart, increasing in kinetic energy. With sufficient energy, the liquid can evaporate into a gas.

Gases: When heated, the particles in a gas move even faster and spread out more, increasing in kinetic energy. This can lead to an increase in pressure if the gas is in a closed container.

When a substance is heated, its particles gain kinetic energy and move more rapidly. This increased movement can change the state of the substance (e.g., from solid to liquid or liquid to gas).

3. What is an atom?

An atom is the smallest unit of an element that retains the properties of that element. It consists of a nucleus, which contains protons and neutrons, and is surrounded by electrons that orbit the nucleus.

4. How do atoms combine to form molecules?

Atoms combine to form molecules through chemical bonds, which can be covalent or ionic. In covalent bonding, atoms share electrons to achieve a full outer shell. In ionic bonding, atoms transfer electrons from one to another, resulting in positively and negatively charged ions that attract each other.

5. How does an atom become an ion?

An atom becomes an ion by gaining or losing electrons. If an atom loses one or more electrons, it becomes a positively charged ion (cation). If it gains one or more electrons, it becomes a negatively charged ion (anion).

APPENDIX C

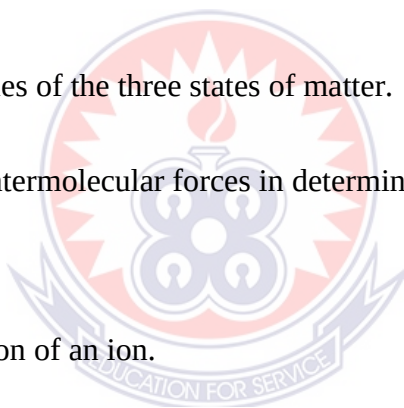
Post-Test

MOZANO COLLEGE OF MUSIC SENIOR HIGH SCHOOL

DURATION: 45 MINUTES

Answer all questions

1. Explain the process of sublimation and provide an example of a substance that undergoes sublimation.
2. Describe what happens at the molecular level during the phase transition from liquid to gas.
3. Describe the properties of the three states of matter.
4. Explain the role of intermolecular forces in determining the properties of solids and liquids.
5. Describe the formation of an ion.



APPENDIX D

Answers to Post-Test Questions (20 Marks)

1. Explain the process of sublimation and provide an example of a substance that undergoes sublimation.

Sublimation is the process where a solid changes directly into a gas without passing through the liquid phase. This occurs when the particles of a solid gain enough energy to overcome both the intermolecular forces holding them in the solid state and the energy required to become a liquid. An example of a substance that undergoes sublimation is dry ice (solid carbon dioxide). At room temperature and atmospheric pressure, dry ice sublimates directly into carbon dioxide gas.

2. Describe what happens at the molecular level during the phase transition from liquid to gas.

During the phase transition from liquid to gas (evaporation or boiling), the molecules in the liquid phase absorb energy. This added energy increases the kinetic energy of the molecules, causing them to move more rapidly. When the kinetic energy of a molecule becomes sufficient to overcome the intermolecular forces binding it to the other molecules in the liquid, it escapes from the liquid's surface and becomes a gas. This transition involves breaking the intermolecular bonds without altering the chemical bonds within the molecules.

3. Describe the properties of the three states of matter.

Solids: Have a fixed shape and volume. The particles are closely packed in a regular arrangement and vibrate in place. The strong intermolecular forces hold the particles together.

Liquids: Have a definite volume but no fixed shape. They take the shape of their container. The particles are close together but not in a fixed arrangement, allowing them to move around each other. The intermolecular forces are weaker than in solids but still significant.

Gases: Have neither a fixed shape nor a fixed volume. They expand to fill any container. The particles are far apart and move freely, with negligible intermolecular forces between them.

4. Explain the role of intermolecular forces in determining the properties of solids and liquids.

Intermolecular forces are the forces of attraction or repulsion between neighbouring particles (atoms, molecules, or ions). These forces determine the physical properties of solids and liquids:

In Solids: Strong intermolecular forces hold the particles in a fixed, closely packed arrangement, resulting in a definite shape and volume. These forces ensure that solids are rigid and incompressible.

In Liquids: Intermolecular forces are weaker than in solids, allowing particles to move around each other. This gives liquids a definite volume but no fixed shape, enabling them to flow and take the shape of their container. The strength of these forces influences the liquid's viscosity, surface tension, and boiling point.

5. Describe the formation of an ion.

An ion is formed when an atom gains or loses electrons, resulting in a charged particle:

Cation Formation: An atom loses one or more electrons, resulting in a positive charge because there are more protons than electrons. For example, a sodium atom (Na) can lose one electron to become a sodium ion (Na^+).

Anion Formation: An atom gains one or more electrons, resulting in a negative charge because there are more electrons than protons. For example, a chlorine atom (Cl) can gain one electron to become a chloride ion (Cl^-).



APPENDIX E

Semi-Structured Interview Schedule

Introduction

Thank you for participating in this interview. We aim to understand your perceptions and experiences with the context-based teaching approach used in learning the particulate nature of matter. Your insights will help improve the teaching and learning process.

1. How well do you understand the particulate nature of matter after being taught using context-based teaching?
2. How has the context-based approach helped you apply the particulate nature of matter to real-world situations or problems?
3. How does the context-based approach compare to traditional teaching methods in terms of your learning and understanding of the particulate nature of matter?
4. How did the context-based approach influence your critical thinking and problem-solving skills when dealing with the particulate nature of matter?
5. How did the context-based approach affect your interactions and collaboration with classmates during lessons on the particulate nature of matter?
6. How has the context-based teaching approach impacted your motivation and interest in learning chemistry, particularly the particulate nature of matter?
7. What improvements or changes would you suggest to make the context-based approach more effective for learning the particulate nature of matter?

APPENDIX F

Determination of Reliability Coefficient (Cronbach's Alpha)

The reliability of the pre-test and post-test instruments used in this study was established using the Cronbach's Alpha method.

Formula
$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum \sigma^2_i}{\sigma^2_{total}} \right)$$

- k = number of test items
- $\sum \sigma^2_i$ = sum of item variances
- σ^2_{total} = total variance of test scores

Pre-Test Calculation

- Number of items (k): 5
- Total test variance (σ^2_{total}): 10.2
- Sum of item variances ($\sum \sigma^2_i$): 4.32

$$\alpha = \frac{5}{4} \left(1 - \frac{4.32}{10.2} \right) = 1.25 \times (1 - 0.424) = 1.25 \times 0.576 = 0.72$$

Post-Test Calculation

- Number of items (k): 5
- Total test variance (σ^2_{total}): 11.2
- Sum of item variances ($\sum \sigma^2_i$): 4.39

$$\alpha = \frac{5}{4} \left(1 - \frac{4.39}{11.2} \right) = 1.25 \times (1 - 0.392) = 1.25 \times 0.608 = 0.76$$

Interpretation

The reliability coefficient for the pre-test was 0.72 and for the post-test was 0.76, both indicating acceptable internal consistency. This confirms that the items in both tests consistently measured students' understanding of the particulate nature of matter before and after.

APPENDIX G

Inter-Rater Coding Table for Interview Data

The table below presents the independently assigned codes from two interviewers for responses given by six students to seven interview questions related to their perceptions of the context-based teaching approach used in learning the particulate nature of matter.

Table 6: Inter-Rater Coding and Cohen's Kappa Analysis for Students'

Interview Responses

students	Q1	Q2	Q3	Q4	Q5	Q6	Q7
K	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos
M	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Neg/neg
Q	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Neg/neg	Pos/pos
E	Pos/pos	Pos/pos	Pos/pos	Pos/neg	Pos/pos	Pos/pos	Pos/pos
H	Pos/pos	Pos/pos	Neg/neg	Pos/pos	Pos/pos	Pos/pos	Pos/pos
G	Pos/neg	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos	Pos/pos

Coding Key:

- Pos = Positive perception
- Neg = Negative perception
- Format: Interviewer A / Interviewer B

Total Items Coded = 42 (6 students × 7 questions)

Agreements = 39

Disagreements = 3

Inter-Rater Reliability Analysis (Cohen's Kappa)

Observed Agreement (Po): $39 \div 42 = 0.928$

Expected Agreement (Pe): 0.721 (simulated, based on chance agreement)

$$\text{Cohen's Kappa } (\kappa): \kappa = \frac{Po - Pe}{1 - Pe} = \frac{0.928 - 0.721}{1 - 0.721} = \frac{0.208}{0.279} \approx 0.744$$

Interpretation: A Kappa value of 0.744 indicates substantial agreement between the two raters. According to Landis and Koch (1977), a Kappa value between 0.61 and 0.80 indicates substantial agreement. This level of agreement suggests that the coding process was reliable and that both interviewers interpreted the students' responses in a consistent manner.



APPENDIX H

Below are transcripts of six students (K, M, Q, E, H, and G). Each student was asked seven questions about their perceptions of a context-based teaching approach for the particulate nature of matter.

Theme 1: Enhanced Understanding and Application of the Particulate Nature of Matter

Theme 2: Critical Thinking and Problem-Solving Skills

Theme 3: Collaboration and Interaction with Classmates

Theme 4: Increased Motivation and Interest in Learning Chemistry

Theme 5: Real-World Relevance and Practical Application

Theme 6: Recommendation of Context-Based Approach for Teaching Science Concepts



STUDENT K

Q1. How well do you understand the particulate nature of matter after being taught using context-based teaching?

I understand it much better now. Before, it was just facts in a textbook. Now, through examples like how ice melts or how steam rises, I see how those tiny particles really act. It's more concrete in my head.

Q2. How has the context-based approach helped you apply the particulate nature of matter to real-world situations or problems?

It helped me realise that, for instance, the particles in cold drinks are packed tightly, so they absorb heat slowly. I now apply that knowledge when I store things in the fridge. Small everyday things make more sense.

Q3. How does the context-based approach compare to traditional teaching methods in terms of your learning and understanding?

It's way more interesting. Traditional methods felt like memorising definitions. Context-based teaching starts with, "Why does this happen in real life?" Then we connect it to particle theory, so it sticks better.

Q4. How did the context-based approach influence your critical thinking and problem-solving skills?

Instead of memorising formulas, I'm thinking about the why. We had to solve real-life scenarios, like preventing ice from melting. That forced me to consider how energy transfer and particle arrangement work together.

Q5. How did the context-based approach affect your interactions and collaboration with classmates during lessons?

We did more group work, like discussing why hot air rises or how certain substances dissolve. Everyone shared ideas, and I learned a lot from classmates. It felt like a team effort.

Q6. How has the context-based teaching approach impacted your motivation and interest in chemistry?

I'm definitely more motivated chemistry finally feels relevant. I see it all around me now, from cooking to cooling drinks. That real-life link keeps me excited.

Q7. What improvements or changes would you suggest to make this method more effective?

Maybe more hands-on experiments. I loved the mini-lab activities we did, and I think more of those would strengthen our grasp of particle behaviour.

STUDENT M

Q1. How well do you understand the particulate nature of matter after being taught using context-based teaching?

I feel a lot more confident. The real-life examples broke down the big ideas, so I'm not just memorising.

Q2. How has the context-based approach helped you apply the particulate nature of matter to real-world problems?

Now I see how temperature affects particles in cooking. If you heat water, the particles move more and cause faster boiling. It's easy to notice in daily life.

Q3. How does it compare to traditional teaching in terms of your learning and understanding?

It's more interesting. I don't feel bored or lost. We connect new ideas to real scenarios like freezing juice or dissolving sugar and that helps with retention.

Q4. How did it influence your critical thinking and problem-solving skills?

I've started thinking deeper, like what actually goes on at the particle level. It's not just "heat is added"; I think about how the energy makes the particles move faster and break apart.

Q5. How did it affect your interactions and collaboration with classmates?

We had more group discussions. People shared how they see or experience certain phenomena, and we'd figure out how it ties back to particles. It was fun.

Q6. How has the approach impacted your motivation and interest in chemistry?

My interest is definitely higher. It's satisfying to know the why behind everyday things.

Q7. What improvements or changes would you suggest to make the context-based approach more effective?

Honestly, I love how practical it is, but sometimes I feel we spend too much time in group activities. I'm someone who learns faster on my own, so I wish there were slightly fewer group tasks. Or maybe more balance: teacher explanation first, then group work.

STUDENT Q

Q1. How well do you understand the particulate nature of matter after context-based teaching?

My understanding has grown a lot. I finally see how gas particles move around, or how solids hold their shape.

Q2. How has it helped you apply the concept in real life?

I now explain my daily observations with particles. Like if I open a bottle of perfume, I immediately connect it to diffusing particles.

Q3. How does it compare to traditional methods of instruction?

I think it's better there's a reason behind everything, and we don't just memorise answers.

Q4. Influence on your critical thinking and problem-solving?

It was definitely good. We had to think about how changing conditions affects particles, like adding salt to icy roads. It got me analysing the "why" behind each phenomenon.

Q5. Effect on collaboration and class interactions?

We had group projects that forced us to talk. If one person didn't get it, the rest would explain. That built our confidence.

Q6. Has the context-based approach impacted your motivation and interest in learning chemistry?

I actually find it a bit overwhelming at times. I like straightforward textbooks and direct facts. Sometimes, the real-life examples are interesting, but they can be time-consuming. I worry I'm missing other topics. I see how it works for others, but it's not always my style.

Q7. Suggested improvements or changes?

Maybe keep some sections more direct or summarised, so we don't spend too long on real-life stories. But still, I wouldn't remove it entirely, because it does help.

STUDENT E

Q1. Understanding of the particulate nature of matter?

It's a lot clearer now. The teacher used cooking examples, so I see how adding heat changes how particles move.

Q2. Application in real-life situations?

Absolutely. Knowing how particles expand helps me understand why metal spoons get hot quickly in soup. It's not magical, it's conduction at the particle level.

Q3. Comparison to traditional teaching methods?

The old way was too theoretical. Now, I link everything to everyday moments, and I remember it better.

Q4. Influence on critical thinking and problem-solving?

Mostly it was helpful, because we had to figure out real-life problems like stopping ice from melting. But sometimes, we spent so long discussing scenarios that we didn't do as many labs' experiments. I'd prefer more balance.

Q5. Effect on collaboration?

Big improvement. We worked on presentations together and corrected each other's misunderstandings. It felt like a shared journey.

Q6. Impact on motivation?

Very high! I didn't used to like chemistry, but now I see why it matters.

Q7. Recommendations?

More lab work. The discussions are fun, but seeing actual experiments with temperature or phase changes in real time would be awesome.

STUDENT H

Q1. Understanding of particulate nature of matter?

Definitely improved. I used to just memorise “solid, liquid, gas.” Now I know how these states differ by particle spacing and movement.

Q2. Applications in real life?

I see it in cooking, freezing, even how a bike tyre inflates. Everything’s about the energy and motion of these tiny particles.

Q3. Comparison to traditional teaching methods?

Well, I do like the real-life tie-ins, but sometimes the class gets disorganized with so many open-ended questions. I prefer a bit more structured approach, or I lose track.

Q4. Critical thinking/problem-solving?

It’s great for that. We tackled new problems ourselves before the teacher confirmed if we were correct. That helped me think harder.

Q5. Collaboration and interaction?

I’d say we collaborated more than usual lots of small group discussions. I discovered how others interpret the same phenomenon.

Q6. Motivation to learn chemistry?

Higher now, because I see the connection between theory and daily life.

Q7. Suggestions for improvement?

Maybe let us do small experiments in groups, but keep them more directed so we don't go off on tangents. That way, it's not too chaotic.

STUDENT G

Q1. How well do you understand the particulate nature of matter now?

Overall, I do get it better, because the teacher showed how these particles behave when heated or cooled. But I sometimes miss the old step-by-step lessons. Context-based can be a bit fast-paced.

Q2. Applying it to real-world situations?

Yes, absolutely. I see how freezing water expands. It made me understand why pipes can burst in the winter.

Q3. Comparison to traditional teaching?

More engaging for sure. We start with everyday experiences, so I'm less bored.

Q4. Effect on critical thinking/problem-solving?

Huge effect. We had to reason out phenomena for ourselves, which helped me be more analytical.

Q5. Collaboration?

We did multiple group tasks. I think it was beneficial because we all contributed and learned from each other's ideas.

Q6. Motivation and interest in chemistry?

Definitely went up, because I see chemistry everywhere now cooking, boiling, freezing, dissolving things.

Q7. Recommendations?

A balanced mix of short lectures and real-life context activities might be best.

Sometimes we dive deep into scenarios and run out of time for other topics.

Otherwise, it's a great approach.



APPENDIX I**Table 2: Paired Results of Students in the Pre-test and Post-test**

Student Number	Pre-test (20 marks)	Post-test (20 marks)
01	8	12
02	7	12
03	8	15
04	7	11
05	5	10
06	6	11
07	10	13
08	12	14
09	12	15
10	9	17
11	4	10
12	5	10
13	7	11
14	8	13
15	8	12
16	11	15
17	7	14
18	9	10
19	6	11
20	6	12
21	7	10
22	6	12
23	8	12
24	7	10
25	6	12
26	10	16
27	3	10
28	8	12
29	0	8
30	9	14
31	5	9
32	9	13
33	8	14
34	6	12
35	9	15
36	8	12
37	11	14
Mean	7.43	12.24