UNIVERSITY OF EDUCATION, WINNEBA

REMEDIATING STUDENTS' MISCONCEPTIONS IN SOME INTEGRATED SCIENCE TOPICS THROUGH THE CONCEPTUAL CHANGE MODEL

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DECLARATION

Student's Declaration

I, Saraphina Afriyie Acheampong, 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:………………………….........................

Supervisors' Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Education, Winneba.

Name**:** Prof. Mawuadem Koku Amedeker

Signature:………..…...

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

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I owe a special debt of appreciation to Professor Mawuadem K. Amedeker, my supervisor, for his unwavering encouragement and advice, as well as to Samuel Osei Opoku and Caleb Akomeah, two of my closest friends, for their prayers.

DEDICATION

To my parents, Mr. and Mrs. Acheampong and to all my siblings.

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ABSTRACT

This study investigated students' misconceptions regarding the concepts of force, motion, and pressure at Wesley Girls' High School and evaluated how well these misconceptions might be corrected through the use of a conceptual change model teaching strategy. The conceptual change theory served as the foundation for the study's framework. For the study, an action research design was used. Eighty students were selected for the study from two Form 2 General Art classes at Wesley Girls' High School using a purposeful sampling strategy. Students' misconceptions were investigated using the Students Misconception Diagnostic Test (SMDT). Over the course of a month, the students were instructed utilising the conceptual change model. In order to distinguish between the variations in the students' academic achievements, the SMDTs were then carefully structured and administered to the students as the Science Performance Test (SPT). The SMDT results showed that students lacked understanding and had serious misconceptions regarding the concepts of force, motion, and pressure. A quantitative analysis (t-test) was done to determine students mean scores between the SMDT and SPT. Results from the analysis revealed that the Conceptual Change Model strategy is a strong strategy to remediate students' misconceptions. Students mean scores from the SPT was significantly higher ($m = 1.42$, $SD = 0.497$) than the mean scores from the SMDT ($m = 1.00$, $SD = 0.00$, $t = -2.054$, $p < 0.001$). Eight students from each class made up the group of 16 were interviewed to find out how they felt about the conceptual change model as an intervention. A qualitative analysis of the data was performed. The interview segment also demonstrated that after using the CCM approach, the majority of students' misconceptions about force, motion, and pressure were cleared up. It is therefore recommended that before beginning lessons, science teachers are advised to ascertain their students' preconceptions in order to correct any misconceptions regarding the concepts of force, motion, and pressure utilising the conceptual change model approach.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter serves as the study's introduction. It also focuses on the issue that prompted the Researcher to conduct this study. This chapter also addresses the problem's evidence, as well as the study's purposes, objectives, and significance. The study's research questions, limitations, delimitations, and definition of terms and concepts are briefed in this chapter.

1.1. Background to the Study

In educational settings, a variety of factors influence learning, and misconception is one of the significant factors. Students come to class with varying ideas, experience, beliefs and also their own preconceived notion (Chen, Sonnert, Sadler, Sasselov & Fredericks, 2020). Some of these experiences or ideas are scientifically incorrect, and this is term as misconception.

Science misconception is a mental model created by students to help them understand scientific concepts that contradict scientists' accepted beliefs (Prokop & Fancovicova, 2006). Halim, Finkenstaedt-Quinn, Olsen, Gere, and Shultz (2018) posited that, students' misconceptions are obstacle in science, technology, engineering, and mathematics courses and, unless remediated, may continue to cause difficulties in learning as students advance in their studies. For this reason, the researcher seeks to use Conceptual Change Model (CCM) as an intervention to remediate students' science misconceptions, which can create difficulties in science teaching and learning. Conceptual change model is a learner-centred model that leads students through activities that directly challenge their personal misconceptions**.** This model was created by Posner, Strike, Hewson and Gertzog (1982), as a model of science instruction based on identifying and correcting student misconceptions. Conceptual change can occur when students' prior knowledge conflict with the new information presented to them.

1.2 Statement of the problem

It has been found that some of the preconceptions of the material that students bring to the science classroom are scientifically inaccurate (McComas, 2006). Moreover, students are usually not aware of their misconceptions, and how they contradict scientific knowledge (Safo-Adu, 2020). This makes the learning of science challenging for students in Senior High school, and if not remediated can lead to their acquisition of little understanding, knowledge, and skills on some Integrated Science topics. Hence, there is the need to diagnose and remediate students' misconceptions. The trust of this research is aimed at remediating Form two students in Wesley Girls' High School misconception in some integrated science topics using conceptual change model.

1.3 Purpose of the study

The purpose of this study was to use the conceptual change model to remediate the misconceptions of Form two students in Wesley Girls' High School misconceptions in some Integrated Science topics.

1.4 Objectives of the Study

This study was focused on the following objectives. To:

1. diagnose Integrated Science students' misconceptions on some Integrated Science topics.
2. determine the effect of the conceptual change model in remediating these students' misconceptions.

3. identify Integrated Science students' perceptions of the use of the conceptual change model as a teaching strategy in remediating their misconceptions.

1.5 Research questions

1. What are some of Integrated Science students' misconceptions about some topics in Integrated Science?
2. What effect does the Conceptual Change Model have on changing the students' misconceptions on some Integrated Science topics?
3. What are Integrated Science students' perceptions of the Conceptual Change Model as a teaching strategy for changing their misconceptions about some Integrated Science topics?

1.6. Research hypothesis

H_0: there is no significance difference in the mean scores of students' pre-test and post-test when exposed to conceptual change model strategy on some selected topics in Integrated Science.

1.7 Significance of the Study

The use of traditional science instruction that depends primarily on the presentation of scientific concepts without the thoughtfulness of the student's misconceptions can be somewhat ineffective. Therefore, findings from this study are significant for the following reasons:

1. The study will be beneficial to Wesley Girls' High school students who participated in this study by improving their academic performance and changing their misconceptions.

2. Science teachers in Wesley Girls' High school will be motivated to promote Conceptual Change Model to remediate their students' misconceptions.
3. The study will also create materials that other teachers can use to identify and address science misconceptions in their classrooms.
4. Finally, the study will contribute to the existing literature on the use of the Conceptual Change Model in science education.

1.8 Limitations of the Study

The potential weakness in a study that is not within the researcher's control is known as a limitation (Simon, 2011). This study was limited by inadequate finances and organization; therefore, more students were not involved in the sample**.** Also, anxiety on the part of students in terms of the responses to the questionnaire and the test item possibly affected the result of this study. To minimize the effect of this anxiety, the research participants were made aware that the outcomes of the questionnaire and the test items administrated to them are not for any academic purposes, but solely for research purposes.

1.9 Delimitations of the Study

This study sampled only second-year students in Wesley Girls' High School to participate in the study, the study was focused only on the following science topic; Force, Motion, and pressure. The researcher believes that, probably, the identified problem is not limited to the chosen class, form, or even the school but due to the research design that was adopted and other constraints, the study was not extended beyond the selected class or form.

1.10 Definition of Terms

Some terms were used in this study that may have a different contextual meaning.

Concept: this is a generalized idea that represents a class of objects or events. A concept is an abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbol, that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them.

Conceptual change: this implies that a learner actively and rationally replaces existing pre-scientific conceptions with scientifically acceptable explanations as new propositional linkages are formed in his conceptual framework.

Conceptual Change Model (CCM): It is a student-based model that guides the learner through activities that directly challenge their misconceptions.

Science Misconception: A mental model created by students to understand scientific concepts that differ from the accepted beliefs held by scientists**.**

1.11 Organization of the study

The description of this study was presented in five chapters. The first chapter dealt with the background to the study, statement of the problem, the purpose of the study, objectives of the study, research questions, hypotheses, significance of the study, limitations of the study, delimitation of the study, and organization of the chapters of the study. Also, some terms used in the study were defined in the first chapter.

The review of existing relevant literature was presented in chapter two. Chapter three discussed the methodology which encompasses the design of the study, study area, populations, sample size and sampling technique, instruments, and data collection procedure as well as the method of data analysis. Chapter four presented the results and the discussions of the findings. Lastly, the summary of the main findings, conclusions, recommendations, and suggestions was presented in the fifth chapter.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter presented a review of related literature to the study. The literature was reviewed under the following sub-headings:

- The Nature of misconception
- Sources of misconception
- How to identify students' misconceptions
- Definition of conceptual change
- Challenges with Conceptual Change Research
- The Conceptual Change Model (CCM)
- Process of Conceptual Change Model
- Element critical to conceptual change model
- The importance of conceptual change in science education
- Downfalls of Conceptual Change Model
- Theoretical framework for conceptual change
- Conceptual framework for conceptual change
- Implication of conceptual change model

2.1 The Nature of Misconception

Evidence has shown that the traditional "tabula rasa" view of student understanding has deeply been opposed, because our world is filled with science, and a simple walk outside creates a multitude of mental models about the way science works for our students (Salierno, Edelson, & Sherin, 2005). When students learn a new concept, many of them already have some prior understanding of that concept. Students may also have inexperienced or pre-conceptions theories in their minds about the new or experienced concept. Researchers refer to such inexperienced concepts as misconceptions. According to Tomita (2008), Misconceptions can be identified as students' prior knowledge which is embedded in a system of logic and justification, although it may be incompatible with accepted scientific understanding. According to the constructivist theory, students generate knowledge and meaning from their previous experiences, this creates misconception when the already existing experience contradicts the new scientific experience presented to them. Usually, misconceptions are robust, very resistant to change, and deeply rooted in everyday experience, and often new information presented by the instructors comes to conflict with already existing students' mental models (Goris, 2010). Based on the analogy used by O'Brien (2010) concerning constructing a house, just as you cannot build a solid framework for a house on a weak foundation, is the same way you can't construct new meaning from flawed background knowledge. Science misconceptions are formed whenever a student interacts with the world and can present as important roadblocks to correct understandings of scientific concepts (Mckenna, 2014). Misconceptions can be obtained before enrolling in any school program or generated at any point during formal education. Other researchers referred to Misconceptions as naive beliefs, erroneous ideas (Ferrero, 2020), preconceptions, and also alternative conceptions (Kambouri, 2015). Research reveals that misconception is hard to eliminate through traditional approaches because it is a permanent and continuous process, and it is not sufficient to develop the right concepts in students (Tekkaya et al., 2000). Misconceptions are really difficult to get rid of because of how deep-rooted they are in the student's minds. This is because students have held these naïve ideas for a very long time and they make meaning to them, therefore getting rid of such ideas becomes problematic. Students may be completely unaware that their understanding is incorrect, and this can hinder their ability to learn by interfering with the learning process and inhibiting their learning in students (Kutluay, 2005). Kutlualy (2005) also proposed that, in the fear of failing in examination, students' rote learn the scientific and non-scientific concepts with their target being only to clear the examination, although they can pass almost any exam through the memorization of basic problem skills, they do not understand the principle involved in the solution of the problems. This result in difficulties in teaching and learning science as students receive new ideas or fact given by the teacher and therefore, bring confusion and disagreement with the scientific concept.

2.2 Sources of misconception

Several research studies have shown that many sources of misconceptions exist in students. According to (Haruna, Antwi, & Asante, 2021), students' misconceptions can be generated from their everyday life experiences, their cultural or religious beliefs, and also incorrect information presented to them by their parents, teachers, or other people in their society. Misconceptions also arise due to the common use of scientific terminology in day-to-day language, in other words, misusing the scientific concept (All answers Ltd, 2018). Another source of students' misconceptions is how they combine new information presented to them with the previously held concept, this may bring about disagreement in students' minds. According to (Tekkaya, 2002), misconceptions are passed from teachers to students through wrong or inaccurate teaching. Some teachers transfer misconceptions to their students in the classrooms by using words and certain terms in a non-scientific context to explain scientific concepts to them, this creates confusion in students. Since the science concept is not clear in the teachers' minds, they may end up misleading the students in the course of explanation. (Anam llyas, 2018) posited that, textbooks used by teachers in the teaching of science concepts are also one of the sources from which misconceptions can emerge. Thus, the difficulty of language used in the textbooks may confuse some students to a great extent. And also, instruction written in some science textbooks fails to identify what students' initial ideas are, and this leaves students' inaccurate ideas unchanged.

2.3 How to identify students' misconceptions

The best way to deal with students' misconceptions is first to find them, then confront them, and eventually, reconstruct them. The first step in dealing with students' misconceptions is to identify if students have any misconceptions and if they do, it's important to discover what they are. Research has shown many strategies which may be used to highlight and identify students' misconceptions in the science classroom. Students' misconceptions are identified and addressed through the method of questioning and listening ((Haruna et al., 2021). Asking students' opinions on the subject to be taught, and more significantly taking note of them is an effective way to identify what students understand and don't understand. Other strategies for identifying students' misconceptions include developing diagnostic tests for college kids to discover their conceptual understanding before the topic, having a category discussion about the topic before instruction with students, and also allowing students to debate with their peers their prior knowledge concerning the topic to be taught and compare ideas (Musolfnj, 2020). Sometimes identifying students' misconceptions are often time-consuming, but before students' misconceptions are often best remediated, there's the need to identify them. Smith also proposed that pre-assessment quizzes are often an effective way to measure academic growth in a particular topic, this will be achieved by comparing what the students already know at the start of a topic and what they know at the end. This pre-assessment quizzes are often accomplished at the start of a topic and can be reviewed to identify any common misconceptions. Once students' misconceptions are detected, there's the need to remediate them by modifying the correct information with the teacher's own experience and understanding.

2.4 Definition of conceptual change

Conceptual change has been defined in some ways. Conceptual change deals with a process of accommodation, a process during which schema is changed when learners are exposed to new information that does not fit with their existing conceptions. The vital thing to stay in mind is that in accommodation, new schemas don't replace or supplant old schema, as people may simultaneously hold multiple schemas to elucidate the phenomenon (Shtulman, 2009). The new schema rather holds greater clarifying power with the experienced situation and thus is more likely to be considered and to become the dominant conception used to explain the phenomenon in a given situation or context (Nadelson, Heddy, Jones, Taasoobshirazi, & Johnson, 2018). Thus, conceptual change makes emphasis the very fact that individuals recall their prior schemas when that schema is modified (or restructured), which results in a change in ideas or conceptions. Conceptual change may be a process of building on existing information to form a new description while recalling an explanation of the original existing conception. The results of the modification become the preferred conception while the original conception is retained and can still be relied on to explain the phenomenon, as people may hold multiple conceptions to elucidate a specific phenomenon (Ohlsson, 2009; Shtulman, 2009). Alparsian et al also posited that the theoretical models describing learning as a lively process in which learners become aware of and reason about conceptual relations, or as a process of conceptual refinement, is understood as conceptual change.

This suggests that conceptual change can simply be defined as the development of basically new concepts, through restructuring the existence of old concepts, within the course of knowledge achievement or acquisition.

2.5 Challenges with Conceptual Change Research

For the past decades, researchers face the challenge to supply answers to the questions; what exactly are misconceptions, what institutes conceptual change, and why conceptual change is so difficult to stay unclear. to supply vivid meaning to these questions, it should be made clear that preconception held by students have to be restored, though preconception is extremely resistant to change, and what constitute these preconceptions should be established. thanks to this, Chi and Roscoe (2002) defined conceptual change because of the process of removing misconceptions. The researchers based their definition on the idea that misconceptions are mis-categorization of concepts. Thus, misconceptions are concepts categorized into an inappropriate category, and conceptual change is simply a process of reassigning or 'shifting' a miscategorized concept from one 'ontological' category to another 'ontological' category (Chi & Roscoe, 2002). This conceptual shift becomes challenging when students lack awareness of their misconceptions which contain difficult-to-grasp principles and concepts and are surrounded with unexperienced theories. These inexperienced theories are difficult to differentiate from correct theories and if awareness is not created among students in their learning process, incorrect understanding could also be generated and this can cause difficulty in future learning.

Nadelson et al (2018) also proposed that, in knowledge acquisition, new information is learned and typically doesn't compete with existing conceptions. consistent with these researchers, if a learner holds a conception, then forms a new conception of the same phenomena, the conceptions may complete or interfere with future learning and every may be reinforced by different experiences or phenomena. This will be a challenge relating to conceptual change research in the sense that, students hold multiple conceptions a few particular phenomena simultaneously. The researchers made emphasis on the very fact that, if a student holds previous knowledge on a specific concept, for instance, 'batteries', learning how batteries work wouldn't require the destruction of the student's already existing conception of the batteries. However, students may hold the concept that batteries are reservoirs of electrons, that get "used up" over time and then learns that batteries involve redox reactions that free up electrons that can flow in a circuit. The students' experiences with older batteries during a flashlight that is dimly lit may reinforce the reservoir conception by supporting the perception that the light is dim due to electrons in the battery being used up. Thus, when faced with having to elucidate batteries, the scholar may rely on and apply multiple conceptions of how batteries work to explain different conditions or processes that are based on the same phenomenon (Nadelson et al, 2018).

2.6 The Conceptual Change Model (CCM)

Alparslan, Tekkaya, and Geban (2003) defined the conceptual change model (CCM) as a theoretical model which describes learning as a lively process, during which learners become aware of and reason about conceptual relations, or as a process of conceptual improvement. Rusanen (2014) posited that conceptual change may cover several sorts of phenomena instead of referring to a singular type of learning. Research conducted on the conceptual change model (CCM) has shown that it's an effective tool for remediating students' misconceptions and improving their learning. The conceptual change model (CCM) was proposed by (Posner et al., 1982) as a model of science instruction supported identifying and correcting student misconceptions. The researchers proposed four fundamental conditions that require to be fulfilled before conceptual change can happen in science learning:

(1) There must be dissatisfaction with existing conceptions; learners create the foremost important conceptual changes only when they believe that less intelligible changes will not work

(2) There must be a replacement conception that is intelligible; the learner should be able to appreciate how understanding is structured appropriately by a new conception to agree to explore the potentials inherent in it.

(3) The new conception must appear to be plausible and may solve problems generated by its predecessors. The new conception gained must be suitable with other knowledge and understanding; otherwise, it'll not give the idea of a plausible choice.

(4) The new conception should suggest the likelihood of a fruitful program. Posner et al. (1982) also argues that hypothetically, CCM has two detectable components in learning activities; thus, status and conceptual ecology. Consistent with (Yip, 2001), the most purpose of science learning is not on how students can remember or memorize accurate subject matter, but be ready to understand concepts carefully. The conceptual change model help students understand concept carefully and challenge them to vary their naïve conception with accurate scientific conception. consistent with Özdemir and Clark (2007), the conceptual change theory proposed by Posner et al (1982), perceives conceptual change as quite just a socio-cultural interaction or a teaching strategy, but as a process of identifying prior misconceptions that the learners carry into the environment to assist the learner

exchange the misconceptions or add new conceptions that are more useful, plausible and intelligible.

2.7 Process of the Conceptual Change Model

Posner developed the Conceptual Change Model technique in the mid-1980s (Posner, 1982). The Conceptual Change Model Lesson comprises six phases, which include the subsequent (Schmidt, Saigo & Stepans, 2006):

1. Before the beginning of the class, students plan their concepts. they need to recognize or explain their reasoning and become conscious of their thought processes.
2. Through dialogues with the teacher or their peers, students share their beliefs with others. They will converse with others, share in groups, and have discussions in order that everyone is aware of the various worldviews present in the class.
3. Students engage during a series of constructivist-based activities and experiments that force them to examine their assumptions. They need to be given the chance to question their assumptions.
4. Students can then accept new information and reconstruct their prior notions through teacher-facilitated debate and peer sharing.
5. Following this, students are urged to check out their newly developed mental schema by making comparisons with various circumstances and experiences and by adapting their thinking to various new contexts.
6. The sixth and end entail giving students the chance to expand their thoughts beyond the parameters of the session. This could be done by asking the pupil questions that could be addressed in a subsequent lesson or independent study project (Schmidt et al., 2006).

The learner's capacity for self-reflection and an environment within the classroom that encourages it is essential for the effectiveness of conceptual change instruction. "Learning should place more of a stress on discovering than on memorization, and teaching should involve more questioning than telling. Time should be put aside for small-group discussions, individual student-instructor conversations, and open-ended studies (McDermott, 1996).

The Conceptual Change Model, (Santyasa, 2004) also has six stages:

1) The identification of conceptual and practical issues
2) Debate misunderstandings about the difficulty
3) Demonstrating and drawing analogies after confronting denial
4) The confrontation of evidence for scientific ideas and tenets
5) Concrete conflict and instances from the environment
6) Confrontational inquiries to dramatically increase knowledge application and understanding.

Agiande, Williams, Dunnamah, Tumba (2015) conducted research on conceptual change theory as a teaching strategy in environmental education. The study examined the conceptual change model (CCM) proposed by (Posner et al., 1982) as a modified of the conceptual change theory and the way this theory can be applied in environmental education teaching and learning. The researchers conducted this study in an effort to change misconceptions, practices, and attitudes among learners in formal education. Again, his co-workers practically observed the beliefs of the idea and showed how it can be used to discover learners' misconceptions about some aspects of the environment, and also how it is often applied along with other teaching/learning tools in environmental education to affect permanent change in behaviours. The findings of the study showed that conceptual change may be a powerful teaching concept that can best remediate students' held misconceptions, and thus teachers should take advantage of it and apply it in other domains of learning besides science and environmental education.

To use this model to effect conceptual change, students existing conceptions should create conflict with the new information presented to them. Thus, there must be dissatisfaction with existing conceptions. Students can only make major changes in their perceptions of science unless they accept the very fact that it is essential to change their already existing conception which is scientifically incorrect. One among the conceptual change instructional strategies or models that can be used to change students' inaccurate conceptions is the conceptual change texts. In these texts, the identified misconceptions of the scholars are given first and then students are informed of the scientific explanations supported by examples to create dissatisfaction (Alparslan, Tekkaya, & Geban, 2003). About this, that specific individual must have in mind unsolved problems which are dissatisfied with the ability of his current concept capacity to solve these problems. This current concept that has been made available to the scholars must be appropriate for a new idea to be structured from it. The new concept should be ready to solve problems created by the previous concept; otherwise, the new concept won't seem like a reasonable choice. Lastly, the new concept must provide an additional fruitful research program for the students. The new concept should have the likelihood to offer extensive and new areas for inquiry. Therefore, the teacher should realize the nature of the conceptual change in students, attempt to find the difficulties of students' learning, and work out the strategy and mechanism for conceptual change teaching (Chih-Chiang &Jeng-fung, 2012).

Several stages of conceptual teaching are identified. These stages include; the diagnostic or elicitation stage, where the teachers use diagnostic techniques to seek out the students' existing conceptual ideas and the reasoning behind the idea; secondly, the status change stage, during this stage teachers use designated methods to help students lower the level of their existing incorrect knowledge and increase the level of their correct ideas; and lastly, the evidence of the result , this stage specialise in whether the outcome of the learning process is partly based on the consideration of the prior existing knowledge. The conceptual change model (CCM) is a lively teaching method that emphasizes students' preconceptions (Asgari, Ahmadi, & Ahmadi, 2018). Yenilmez and Tekkaya (2006) used conceptual change texts combined with conference as a strategy to evaluate their students' understanding of plants' photosynthesis. The results proposed by Yenilmez and Tekkaya (2006) showed that conceptual change approaches are wont to correct a large percentage of students' misconceptions. The results also highlighted the thought that misconceptions are stable beliefs that cannot be easily modified or removed by traditional teaching methods. Therefore, conceptual change helps students review their preconceptions and supports the teacher to look at the student's concepts.

Alparslan et al. (2003) investigated the effect of conceptual change instruction on students' understanding of respiration. The researchers used that to work out students' misconceptions held in respiration. These researchers administered Respiration Concept Test to the scholars in two classes of an urban high school. They grouped these two classes into an experimental and control group. The experimental group received conceptual change instruction; while the control group received traditional instruction during which the teacher provided instruction through lecture and discussion methods. Before the instruction, students in both groups were pre-tested to work out their previous understanding of respiration. The findings of this study revealed that students in both groups had an equal understanding of respiration after the pre-test. But after instruction, the result showed that students who receive the conceptual change instruction, produced a significantly greater achievement within the understanding of respiration concepts, and their misconceptions were explicitly addressed. Asgari et al. (2018) investigated the effectiveness of the conceptual change model (CCM) in learning the basic concepts of Electrostatics. The underlying principles of the CCM were derived from the constructivist theory which assumes that learning may be a process of gradual re-crafting of existing prior knowledge. The study detected that Students encounter problems in understanding Physics concepts (such as static electricity), making their perception and understanding often subject to misconception. The findings of this research showed that Conceptual Change Model (CCM) teaching methods are superior to the normal way of teaching and learning physics in detecting and correcting misconceptions (Asgari et al, 2018). The researchers again suggested that the Conceptual Change Model (CCM) may be a successful method to discover and correcting misconceptions. During this regard, this study determined the consequences of the conceptual change model (CCM) on students' learning of some Integrated Science topics as compared to traditional methods of teaching.

2.8 Elements critical to conceptual change

In handling conceptual change among students, numerous factors need to be considered. consistent with Taasoobshirazi, Heddy, Bailey, and Farley (2016), motivation is one among the factors that influence conceptual change in science learning, and it's the most important component when dealing with elements that influence the conceptual change process; and inarguably should be involved in any conceptual change model. Motivation is an expression of the independence of people in their determination to study alternative explanations and form new conceptions.

Motivation is that the determination of an individual to act to engage cognitively, emotionally, and behaviourally in conceptual change processes. The components of motivation that require to be considered in the conceptual change model that is in alignment with self-determined decision-making to engage in conceptual change processes are;

i. personal relevance
ii. task value and
iii. learning goals (Heddy & Sinatra, 2013; Johnson & Sinatra, 2014).

Personal relevance is when a private learns about a certain topic in the conceptual change process and realised that they are interested and have the tendency to impact the determination of his or her engagement in exploring that concept. This engagement is probably going to increase the conceptual change of students (Sinatra, 2005). Consistent with (Bong, 2004; Eccles & Wigfield, 2002), task value refers to learners' perceptions of the interest, relatedness, usefulness, and price of a task, which influences their motivation. Eccles and Wigfield (2002) propose four classifications of task-value, which include intrinsic value (e.g., interest), attainment value (e.g., identity-related), utility value (e.g., usefulness), and price (e.g., effort that the task takes). Because the individual continues to be serious and pays more attention to a task or a topic, the more likely they're to experience conceptual change (Jones, Johnson, & Campbell, 2015). Pintrich (2000) defined learning goal as a critical module of motivation associated with conceptual change due to the possibility of providing a reason for engaging (or not) in achievement-related tasks. Learning goals are grouped into two basic categories; mastery goals and performance. Mastery goals engage students during a task so that they can become competent or master that task. In contrast, performance goals focus mainly on the result and it is standard. Performance goals allow individuals to match themselves to others. A mastery goal mindset is aligned with a propensity for conceptual change to a greater degree than a performance goal mindset (Johnson & Sinatra, 2014). Senko, Hulleman, and Harackiewicz (2011) suggested that combining mastery and performance goals cause greater levels of determination to engage students and also provides higher levels of motivation for conceptual change.

Pekrun & Stephens (2012) made it clear that emotion is one of the important factors that are highly influential on learning and motivation. Emotion may be a feeling that occurs when individuals label their psychophysiological excitement based on their evaluation of stimuli (Pekrun, Goetz, Titz, & Perry, 2002). Consistent with Schutz & Pekrun (2007), emotions have a positive (joy, pride) or negative (anger, hopelessness) valence. Additionally, emotions are often activated such that they cause physiological arousal (anger, joy) or they will be deactivated (boredom, relief) such they cause no arousal (Pekrun & Perry, 2014). Counting on the valence and the activating nature of the emotion, a succeeding and differential impact on conceptual change may occur. Positive activating emotions, within the form of enjoyment, can increase the likelihood and strength of conceptual change (Heddy & Sinatra, 2013). While a decrease in negative emotions are often significant in conceptual change (Heddy et al, 2017). The connection between conceptual change and emotion was argued by Gregoire (2003), the researcher proposed that emotional responses are triggered before engaging with the message and "as a part of the appraisal process, function additional information for individuals as they interact with a complex, stressful message". Gregoire (2003) further proposed that negative emotions are likely to market engaging in systematic and deep processing of the message, while positive emotions may cause shallow engagement with the processing of the message. Consistent with Broughton, Sinatra, and Nussbaum

(2013), students' negative emotions might be tempered through instruction, including small conference and debate, thus increasing the likelihood of conceptual change.

In addition to emotion, attitude is another important component to incorporate when dealing with conceptual change. Consistent with (Hynd, 2003) attitudes can influence cognition and behavior. Attitudes are the general evaluation of an attitude object (person, place, event, or topic), and are described as a positive or negative valence of liking or disliking (Maio, Haddock, & Spears, 2010). Holbrook, Berent, Krosnick, Visser, & Boninger (2005) posited that, our attitudes influence what quite information we seek out and how the information is processed. This suggests that, rather than noticing incoming information accurately, humans use their attitudes as a lens to translate and interpret or perhaps judge information (Maio et al., 2010). Within the exploration of the inseparability of attitude and conceptual change, Sinatra and Seyranian (2015) hypothesize that individuals have either accurate or inaccurate knowledge additionally to positive or negative valence attitudes. Hence, how individuals engage within the conceptual change process is based on the valence of their attitude. As example, if someone features a negative attitude, conceptual change is unlikely (Sinatra, Kienhous, & Hofer, 2014). Attitude may be a vital element of conceptual change that influences the determination of expressing or activating multiple personal variables. These variables include:

i. motivation
ii. emotions
iii. personal epistemology
iv. behaviour (Nadelson et al, 2018).

First, attitude, directly and indirectly, impacts motivation to interact in multiple stages of conceptual change from message consideration to conceptual change (Holbrook et al, 2005). Second, emotions are an expression of attitudes and evidence that exists and suggest initial emotions drive attitudes (Petty & Brinol, 2015), and both will have a successive impact on conceptual change (Heddy et al, 2017). Third, personal epistemologies are essential attitudes and beliefs associated with an individual's perceptions of knowledge and how learning occurs (Muis, Bendixen, & Haerle, 2006), which impacts conceptual change (Taasoobshirazi & Sinatra, 2011).

Fourth, attitudes impact behaviour in such a way that people persevere through challenges in learning and remain resilient in their engagement based on their attitude toward the topic (Skrok, 2007)

Another element critical to the conceptual change model is cognitive engagement. Cognitive engagement occurs when students explicitly interpret, interact with, process, and add up of a message presented to them (Nadelson, 2018). Consistent with Greene, Dillon, and Crynes (2003), deep cognitive engagement leads to a greater tendency for conceptual change than shallow cognitive engagement. (Greene, Dillon, & Crynes, 2003) posited that in deep cognitive engagement the scholars put substantial time and pay attention toward processing information about the main principles and underlying concepts. But shallow cognitive engagement is characterized by rote processing and straightforward memorization of content. Cognitive engagement is a mediator between emotions and achievement (Pekrun & Linnenbrink-Garcia, 2012), and also is a mediator between motivation and conceptual change in science learning (Taasoobshirazi, Heddy, Bailey, & Farley, 2016).

Behavioural and Affective Engagement: Behavioural engagement is viewed because the actions linked with cognitive engagement such as persistence, attention, knowledge-seeking, and self-regulation (Finn & Zimmer, 2012) and is considered as vital for achieving positive learning outcomes (Fredricks, Blumenfeld, & Paris, 2004).

Affective engagement is defined because the level of emotional response is characterized by feelings of involvement with the concept to be learned (Finn & Zimmer, 2012).

Effective engagement has been shown to impact conceptual change (Broughton et al., 2013). Learners who thoughtfully and critically weigh new information concerning their prior knowledge are likely to hunt for additional information and self-regulate their learning. People with the positive effects who embrace knowledge-seeking behaviours will engage deeper in learning and knowledge and have a higher propensity for conceptual change (Nadelson, 2018).

2.9 The importance of conceptual change in science education

Conceptual change is usually related to the introduction of new concepts, elimination of old concepts, the introduction of latest subordinate classifications, and sometimes even alteration of the full method of classification (Thagard, 2014). Research conducted by Lee and She (2010) on the effects of conceptual change teaching practices as compared with traditional teaching suggested that teaching by conceptual change improves students' scientific reasoning and increases their concepts. The conceptual change model allows students to use their existing knowledge, which is their conceptual ecology, to work out whether the different conditions (intelligible, plausible, and fruitful) are encountered. Students don't challenge their existing opinions unless a new conception is stimulated, alternatively they will accept the information as it is.

Therefore, conceptual change within the science classroom which encourages problem-solving and open discussion help students construct an accurate and lasting conceptual framework that becomes useful for their future knowledge acquisition. Asgari et al., (2018) also proposed that:

1. Conceptual change model (CCM) results in better educational development compared to the traditional method of teaching.
2. Students' comprehension improves when CCM is employed rather than the traditional method of teaching.
3. Application of concepts improves by CCM as compared to the normal method of teaching.
4. The speed of students' misconceptions is reduced when CCM is used to teach.

According to (Yenilmez & Tekkaya, 2006), conceptual change approaches correct a large percentage of students' misconceptions. Also, conceptual change helps students review their preconceptions and supports the teacher to look at the student's concepts.

Alparslan, Tekkaya, and Geban (2003) proposed that students' who usually receive conceptual change instruction produce significantly greater achievement in their understanding of concepts, and their misconceptions are explicitly addressed.

Conceptual change model (CCM) teaching methods are superior to the normal way of teaching and learning science and it is used in detecting and correcting misconceptions (Asgari et al, 2018).

CCM development study in science learning shaped the students' knowledge and supported their understanding of a phenomenon and the effect of new information received (Hajron, Mustadi, & Lutfiyatun, E. (2019).

Jonassen, Strobel, and Gottdenker, (2005) stated clearly that, conceptual change is an efficient tool for reconstructing and reorganizing one's understanding of a concept.

Schmidt et al. (2006) showed that through the utilization of the conceptual change model some preconceptions of students can be revealed and some of their misconceptions can be understood and revised.

2.10 Downfalls of Conceptual Change Models

Many conceptual change models are developed by different researchers to address students' misconceptions of concepts. Conceptual change models like the CRKM (Dole & Sinatra, 1998), CAMCC (Gregoire, 2003), BAKCF (Murphy, 2007), DMCC (Nadelson et al, 2018), etc. are highly significant, but nobody educational tool is without some downfalls, so because it is for conceptual change model. One possible downfall of the conceptual change model is that; students' conceptual ecology is usually ignored. That is, students' motives and goals are sometimes not taken into consideration (Strike & Posner 1992). Another possible downfall of the conceptual change model; within the case of using text is the fact that students' answers to conceptual questions can be influenced by their peers and sometimes lead the students to change their answers to conform to that of higher-achieving students within the class to prevent shame (Çepni & Çil, 2010). This sometimes makes it difficult to spot their misconceptions and address them. According to (Nadelson et al, 2018), some researchers fail to require into account the emotions of students when developing conceptual change models (Taasoobshirazi et al., 2016), and their epistemological beliefs (Kuhn, Cheney & Weinstock, 2000), also as their culture and society. These are factors that will influence students' perception of scientific concepts and hence need to be considered when addressing their misconceptions using the conceptual change models.

2.11 Theoretical framework for conceptual change

The key theory that supports this study is Posner's theory of conceptual change. According to Posner et al (1982), before conceptual change can occur, there should be dissatisfaction within the learner's existing conception to abandon it and accept the scientific conception. The scientific conception presented to the learner must be intelligible, plausible, and fruitful.

Hatano and Inagaki (2003) claim that naive idea is generated to make sense of and foresee novel environmental phenomena. Children of all ages make their judgments and predictions about the world they live in. The generated naive understanding is constantly repaired and replaced by new feasible conceptions. According to Chi and Roscoe (2002), these errors are due to incorrect idea classification, and so conceptual transformation is the reassignment of concepts to appropriately identify them. According to Chi and Roscoe (2002), conceptual transformation is the process of rectifying misconceptions. According to constructivist theory, students construct their understanding of their surroundings based on prior knowledge (Hewson & Hewson, 1984). According to Alparslan, Tekkaya and Geban (2003), conceptual change is an active process in which learners become aware of and reason about conceptual relations, or as a process of conceptual refinement.

According to Pintrich, Marx, and Boyle (1993), conceptual transformation is more than that. Because conceptual change must be controlled by the learner, the concept of purposeful conceptual transformation is similar to mindfulness in certain aspects (Salomon & Globerson, 1987). According to Beauchamp (2016), conceptual change does not depend on contradiction, but on equilibrium. Bereiter and Scardamalia (2018) claimed that the intentional learner is fully aware of motivation, cognition, and learning and that the condition of change in a learner's mind is voluntary. The individually generated knowledge is reasonable, according to Hewson and Hewson (1984), and it is usually not personal because the building process is influenced by social experiences. Existing knowledge and socially accepted concepts, on the other hand, block fresh experience interpretation and influence how new knowledge is viewed in any setting. As a result, two people exposed to the same events may have quite different experiences and interpretations, depending on their knowledge foundations and beliefs, as well as the effects of social interaction. According to Vosniadou (2002), the process of conceptual change in learning is a constructivist approach, with the assumption that knowledge is learned in specific domains and theory-like structures. Knowledge gain is characterized by continuing and progressive theory revisions. According to Ivarsson, Schoultz, and Saljo (2002), the unexperienced idea has no role in conceptual development because conceptual change is defined by the acquisition of intellectual instruments. Changes in the employment of specific intellectual instruments cause conceptual change at the social level in this situation. According to Disessa (2002), conceptual change is the reorganization of several types of information into a complex system in the learner's mind. According to this perspective, conceptual transformation is the cognitive reorganization of fragmented naive knowledge.

2.12 Conceptual framework for conceptual change

Students have a different conception about some science topics being taught in the science classroom, due to their own experience in their natural environment. These preconceptions sometimes lead to a misconception of the students, and if not identified and corrected, could lead to failure in their next level of education. However, the major use of the traditional method in our various schools fails to identify these errors and remediate them. Research has shown that the strong teaching strategy that could identify students' naive conceptions, reorganize them or replace them with accurate conception is the conceptual change model (Schmidt et al., 2006). The Conceptual Change Model approach was created in the middle of the 1980s to give teachers a constructivist-based methodology they could employ (Schmidt, et al 2006). A Conceptual Change Model Lesson comprises six phases, which include the following (Schmidt et al., 2006):

1. Before the start of the class, students commit to their concepts. They must recognize or explain their reasoning and become conscious of their thought processes.
2. Through dialogues with the teacher or their peers, students share their beliefs with others. They can converse with others, share in groups, and have discussions so that everyone is aware of the various worldviews present in the class.
3. Students engage in a series of constructivist-based activities and experiments that force them to examine their assumptions. They must be given the chance to question their assumptions.
4. Students can then accept new information and reconstruct their prior notions through teacher-facilitated debate and peer sharing.
5. Following this, students are urged to test out their newly developed mental schema by making comparisons with various circumstances and experiences and by adapting their thinking to various new contexts.
6. The sixth and final stage entails giving students the chance to expand their thoughts beyond the parameters of the session. Yet few science instructors use this strategy in their teaching and learning. The conceptual change model identifies learners' preconceptions, confronts them, and ultimately reconstructs them (Chih-chiang & Jeng-fung, 2012). According to Vosniadou (2008),

effective teaching based on conceptual change must be in the way that students understand the need to change the concept in their minds and should be encouraged to do so. Due to this, the framework of the conceptual change model provides the assumed relationship among the learners' already existing concepts, how these conceptions are scientifically incorrect, and how this naïve conception can be reorganized to form accurate scientific concepts in the learners' minds. The framework for constructing conceptual change is summarised in the Figure.

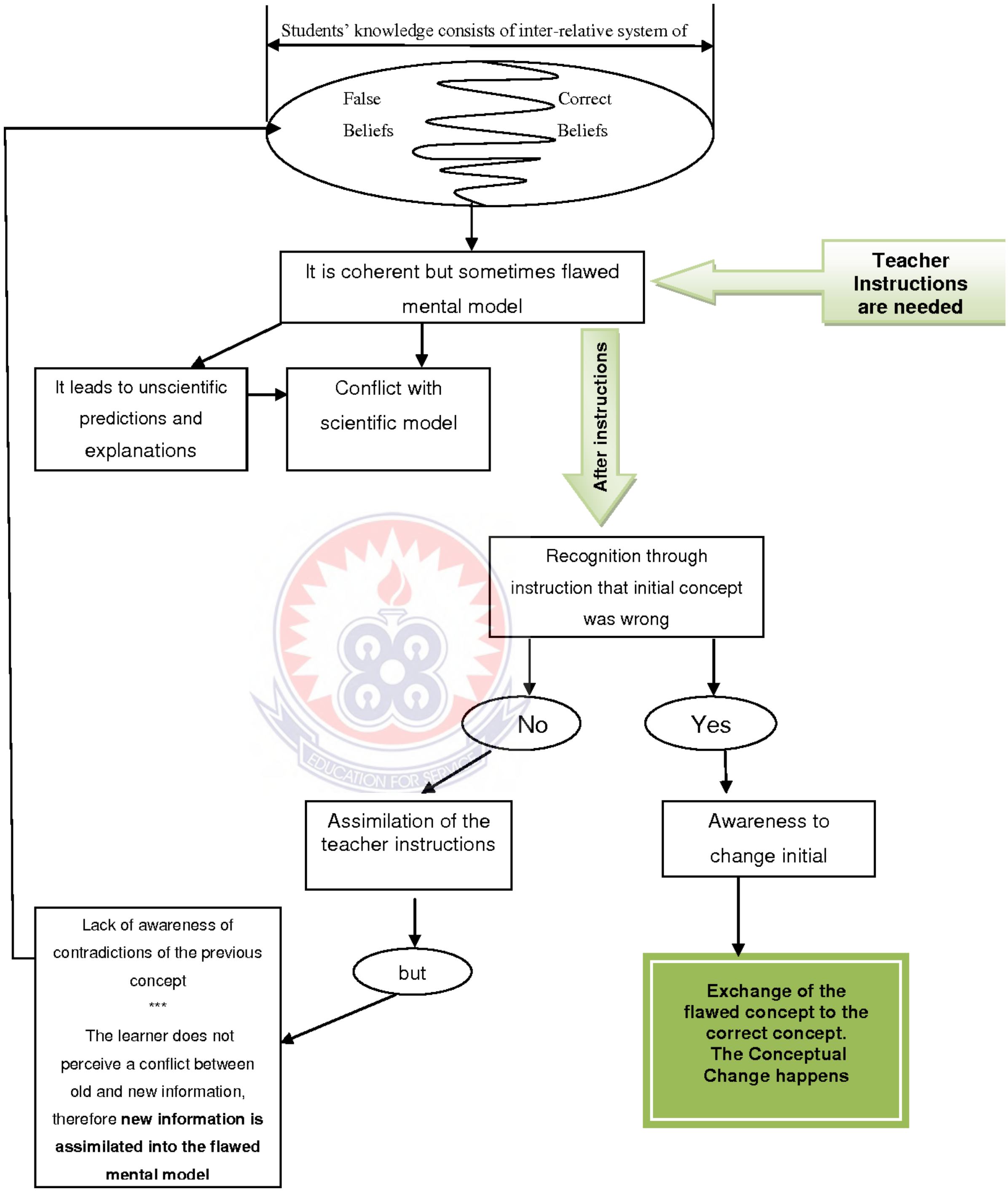

Figure 1: The framework of conceptual change (adapted by Chi, 2009)

2.13 The implication of Conceptual Change Model

The conceptual transformation includes escaping the self-reinforcing cycle of theory-based reasoning, making related changes to numerous ideas, and actively developing a grasp of new (more abstract) conceptual systems. Students' ideas of the natural environment that surrounds them in the classroom can vary greatly. These notions are extremely diverse, and many of them are at odds with the generally accepted scientific idea. When given regular scientific content, students occasionally have these notions of the natural world. This makes conceptual transformation challenging in any situation. The conceptual change model, which enables students to study a concept and gives them the option to read aloud each component of the idea before pausing for class discussion after each section, is the most successful approach, according to (Cetingul & Geban, 2011). According to Özkan and Selçuk (2013), students can use the conceptual change model at home and in any science classroom. For instance, it is said that the conceptual change text is a useful instrument for putting the conceptual change model into practice (Hynd & Alverman, 1997). However, it is proposed that they can be utilized in the classroom vowith a teacher's supervision and direction. Through the application of social constructivism and the conceptual change model, students were able to communicate their ideas and think more clearly, while teachers helped students who were having trouble understanding by offering feedback (Sungur, Tekkaya, & Geban, 2001). In order to demonstrate their understanding of the scientific concept, students are also given a set of questions to respond to at the conclusion of the topic. According to Cetingul & Geban (2011), conceptual change models can come in a variety of shapes, including demonstrations, lab exercises, computer simulations, etc. The purpose of each of these conceptual shift instructions is to get students to check their scientific reasoning for flaws. Murphy (2007) presented a model in which the student's effects and epistemological beliefs infer conceptual change, and the relationship between conceptual development and the change in students' beliefs is viewed as a dynamic and interactive process (Mason, Gava, & Boldrin, 2008). Through the use of a conceptual transformation model, people can develop knowledge snippets that can be applied to enhance conceptions and also describe phenomena. Students can better grasp a phenomenon by using the conceptual change model to finish an explanation.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presented the methodology that was employed in the study. It included the research design, area of the study, population, sample size and sampling technique, instruments that were used, validity and reliability of the instruments used, data collection procedure, and data analysis.

3.1 Research design

According to Kombo and Delno (2006), the research design is a scheme, outline, or plan that is used to generate answers to research problems. It is a detailed documentation of the plan for the collection, measurement, and analysis of data. A research design is a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately, and economically (Kumar, 2011). The research design presents detailed information for the researcher and other readers on all the procedures planned to use and the tasks that are going to be performed to obtain answers to the research questions**.** A research design has so much importance. One of the most important requirements of a research design is to specify everything clearly so a reader will understand what procedures to follow and how to follow them. A research design also answers questions that would determine the path researchers are proposing to take for their research journey. Through a research design, researchers decide for themselves and communicate to others their decisions regarding what study design they propose to use, how they are going to collect information from their respondents, how they are going to select their respondents, and how the information they are going to collect is to be analysed and how they are going to communicate their findings.

In this study an Action Research design was used to solve a practical educational or local problem. Cohen, Manion, and Morrison (2007) define action research as a small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention. Alhassan (2006) proposed that action research is problem-solving research devoted to the solutioan of an immediate problem in a given situation. Kuyini et al (2016) posited that action research is problem-solving research devoted to the solution of an immediate problem in a given situation. The main purpose of action research is to solve classroom problems or a local school problem and to involve classroom teachers to attempt to solve their classroom problems. According to Kumar (2011), most action research is concerned with improving the quality of service. It is carried out to identify areas of concern, develop and test alternatives, and experiment with new approaches. Action Research also equips teachers with new strategies, skills, and methods of teaching and learning new challenging concepts with understanding. In action research, data are collected through a research process, and changes are achieved through action. However, this study was based on the use of the conceptual change model as an intervention in remediating Wesley Girls' High School students' misconceptions on the topic of Force, motion and pressure, Therefore, the researcher considered an action research design as an appropriate design for this study.

The researcher chose an action research design because it enables the use of strategies and initiatives to find an immediate solution to the learning problems, especially the misconceptions students have on the topic; of force, motion, and pressure using the conceptual change model (CCM) as an intervention. The abstract nature of the concept of force, motion, and pressure, and the lack of appreciative teaching strategy that could identify students' misconceptions and at the same time address them have affected the scientific understanding of students on that concept. Hence, this leads to students' poor performance.

This study was done in two main phases. Thus, it involved intervention and post-intervention stages. The intervention stage covered the detailed strategies used to diagnose students' misconceptions on the topic force, motion, and pressure and how these misconceptions were remediated. In this stage, the processes involved in the application of the intervention strategy (conceptual change model) were implemented. The post-intervention stage was applied to determine the effectiveness of the intervention strategy in remediating students' misconceptions and also to identify the perception of students of using such intervention.

3.2 Study Area

The study was carried out in Wesley Girls' High School in Cape Coast Metropolis in the Central Region of Ghana. It is located in Abura- Kakumdo in Cape Coast. According to the population and housing census (2010), the people in Cape Coast are mostly engaged in fishery, forestry, sales workers, craft, and other related trades. There are about 11 Senior high schools in Cape Coast with five being single-sex schools and the rest being mixed schools. Wesley Girls' high school was selected for this study because that is where the researcher is currently working and can have access to some resources that may be easily needed for this study.

3.3 The population of the study

A study population or simply population is a group of people who the researcher wants to find out about and are usually denoted by the letter N. It could be a group of people living in an area, employees of an organisation, a community, a group of people with special issues, etc. The people from whom you gather information, known as the sample n, are selected from the study population (Kumar, 2011). The target population defines those units for which the finding of the study is meant to generalize (Lavrakas, 2008). According to Kannae (2004), the population is the entire group of individuals from which a sample may be selected for statistical measurements. The population of the Study was all Form two students in Wesley Girls' high school, totaling nine hundred and ten (910), offering Integrated Science.

3.4 Sample and Sampling Technique

Sampling is the process of selecting a few respondents (a sample) from a bigger group (the sampling population) to become the basis for estimating the prevalence of information of interest to you. (Kumar, 2011). Sampling means selecting a given number of subjects from a defined population as representative of that population. It makes exhaustive and intensive study possible with much less time, money, and material, (Pandey & Pandey, 2021). The main objective of sampling is to obtain accurate and reliable information about the population with a minimum of cost, time, and energy and to set out the limits of accuracy of such estimates. The number of individuals from whom researchers obtain the required information is called the sample size and is usually denoted by the letter **n**. Two classes (2Arts 3 and 2Arts 4) out of the entire Form 2 classes were selected by purposive sampling for this study with a sample size of 80 (40 students in each class). Two classes were selected because that is the only Form two classes the researcher has been assigned to teach out of the entire Form two classes. Due to this, it is easy to monitor the improvement of the students frequently as compared to the other Form two classes.

Also, according to the Senior High School Teaching Syllabus for integrated science (GES, 2010), the topic of force, motion, and pressure is taught in Form two.

3.5 Research Instruments

The instruments that were used for the study were teaching notes, tests and interviews. This were used to collect data to answer the research questions.

3.5.0 Lesson notes

A lesson note is a list of tasks to be completed while teaching a lesson. It is a certain approach to make sure teachers have fully prepared their classes before teaching them. Teachers are expected to choose topics from the syllabus and provide coherent lessons with definite, quantifiable goals. It requires the teacher to provide evidence of prior knowledge held by students that is pertinent to the new lesson. The record includes a breakdown of the session's material into logical steps, together with the learners' and teachers' activities during the lesson (content development). Additionally, discussed are the teacher's techniques and a thoughtful evaluation plan. The lesson note is an essential tool for the teacher to consider elements that can be unintentionally omitted and disregarded. Lesson notes promote logical thinking in the lead-up to the lesson and boost instructor confidence in front of the class. The teacher is drawn to instructional strategies by the lesson notes. Additionally, it allows the teachers' supervisors to foresee possible issues and challenges that the student and teacher might not be able to notice. It enables the student, teacher, and supervisor to evaluate whether the students have achieved the lesson's objectives both during and after the class. Five lessons on force, motion, and pressure were developed and taught in this study. These prepared lessons were utilized by the researcher to gather information on students' misconceptions of the subject. Questions on force, motion, and pressure were included in the lesson notes and were supposed to be asked before and after each lesson. The questions that were administered before each CCM lesson is known as the Student Misconception Diagnostic Test.

The Students Misconception Diagnostic Test (SMDT) is a set of objective test item that was presented to the students at the beginning of every lesson, as developed in the researchers' lesson notes and also found in (**Appendix B**). This test was used to diagnose the misconceptions students have on the topic of **Force, motion, and pressure.** Also, the researcher used this test to collect information on the student's knowledge of the topic and used it to make an analysis. This test consists of multiple-choice questions (MCQs) and some short-answer questions depending on the content of each lesson. The incorrect answers chosen by participants in the MCQ including wrong responses to short answer questions were considered misconceptions. The researcher used an objective test item because it is a highly objective measurement of students' achievement and they are amenable to the item and statistical analysis. The lesson also consists of teacher-learner activities that the researcher used to address the misconceptions gathered from the Students Misconceptions Diagnostic Test. The lesson notes also contain evaluation questions known as the Students Achievement Question. The researcher asked students these questions to test their understanding of the concept as the lesson is ongoing to verify if the lesson objectives is being achieved.

3.5.1 Test

Eshun and Effrim (2014) posited that a test is an instrument or systematic procedure used for observing and describing one or more characteristics of a student using either a numerical scale or a classification scheme. According to Dzakadzie (2017), a test is a task or series of tasks, which are used to measure specific traits or attributes in people. It answers the question, '***how well does the individual perform***?'' A test is a procedural or device used for measuring a sample of behavior or changes that the learner is expected to demonstrate. The test helps teachers and researchers to assess learners' progress, assess the success of lessons and programs, review teaching/ learning programs, and identify weaknesses and problems of teaching and learning. It also identifies individual differences among learners, motivates learners to learn, and also enables learners to identify their weaknesses and seek assistance. In this study, two tests (pre-test and post-test) were used to collect information on the problem under investigation.

Pre-test

The pre-test is what is referred to as the **Students Misconception Diagnostic Test** (SMDT) that were given to the students before each lesson as developed in the lesson note. The total score of this test was found at the end of the treatment of all the four lessons the researcher taught and used for analysis.

Post-test

The post-test is what the researcher termed a Science Performance Test (SPT). The **SMDT** on each lesson was well-organized and used as the **SPT.** This is to determine ***if there had been any significant difference between learners' new conceptions of the topic force, motion and pressure and their existing conceptions (misconceptions)***. And also, to determine the level of understanding of the students on the concepts of force, motion, and pressure as a result of the intervention strategy.

The Science Performance Test (SPT)

The Science Performance Test (SPT) comprises twenty (20) multiple choice questions and five short-answer questions covering all the five lessons the researcher taught on the **force,** motion, and pressure (Appendix C). The main reason for using the same MCQs and short answer questions as used in the individual SMDT to determine the effect of the intervention strategy (CCM) that was used to teach this topic during the study, and how it has remediated the identified misconceptions concerning the topic. The test items covered the sub-topics; the *meaning of force, types of force, Archimedes* *principle and law of floatation*, *terms associated with motions, inertia, momentum, the centre of gravity and stability of objects*, the *meaning of pressure,* the *effect of pressure in solids, liquids, and gases* as found in the Senior High School teaching syllabus for integrated science (GES, 2010**).** The test item for the MCQs was distributed as follows; eight questions on forces, seven questions on motion, and five questions on pressure. The test items for the short-answer questions were also distributed as follows; two questions on force, two on motion, and one on pressure.

3.5.2 Interview

An interview is a form of questioning characterized by the fact that it employs verbal questioning as its principal technique of data collection. It represents a direct attempt by the researcher to obtain reliable and valid measures of characteristics, behaviours, attitudes, etc. in the form of verbal responses from one or more respondents (Amedahe & Gyimah, 2019). The interview is a flexible tool for data collection, enabling multi-sensory channels to be used: verbal, non-verbal, spoken, and heard. The order of the interview may be controlled while still giving space for spontaneity, and the interviewer can press not only for complete answers but also for responses about complex and deep issues (Cohen et al., 2007). Interviews are expensive in time, they are open to interviewer bias and may be inconvenient for respondents, but it is a powerful instrument for researchers to collect data.

This research work administered Standardized open-ended interviews (Appendix D) to identify the perceptions of students on the use of the conceptual change model as a teaching strategy and how best it has remediated their misconceptions.

According to Cohen et al (2007), in a standardized open-ended interview, the exact wording and sequence of questions are determined in advance. The interview contains seven (7) questions that required students' opinions on the intervention strategy (CCM). All respondents were asked the same basic questions in the same order. This type of interview is significant such that; respondents answer the same questions, thus increasing the comparability of responses, and data are complete for each person on the topics addressed in the interview. This type of interview reduces interviewer effects and bias when several interviewers are used, it permits decision-makers to see and review the instrumentation used in the evaluation, and also it facilitates organization and analysis of the data collected. Some disadvantages of the standardized open-ended interview include; that it provides little flexibility in relating the interview to particular individuals and circumstances; standardized wording of questions may constrain and limit the naturalness and relevance of questions and answers, but it still provided wonderful results to the researcher.

3.6 Validity of the Instruments

Kumar (2011) proposed that validity is the appropriateness of each step in finding out what you set out to do. However, the concept of validity is more associated with measurement procedures. In terms of the measurement procedure, validity is the ability of an instrument to measure what it is designed to measure. Creswell (2012) proposed that the goal of a good research is to have measures that are reliable and valid. Validity is concerned with whether the findings are really about what they appear to be about (Robertson, 2002). Cohen et al, (2007) also highlighted that validity is based on the view that a particular instrument measures what it purports.

The validity of the research instruments was established by first presenting them to the researcher's supervisor for review concerning the content and face validity. To demonstrate content validity, the instrument must show that it fairly and comprehensively covers the domain or items that it purports to cover (Cohen et al, 2007). The researcher ensured this by making the lesson notes and the test instruments cover all the sub-topics in force, motion, and pressure in the Senior High School two integrated science syllabus. The researcher also ensured that the lessons taught and the test items were based on the specific objectives of each lesson. After that, the test items (SPT) were administered to students of the same level from the school other than those selected for the study. The test results were subjected to test item analysis to enable the researcher to reject and replace implausible items and responses. This enabled a reasonable time to be allotted for the test. Also, the lesson notes prepared by the researcher was given to the Head of Department of Integrated science to go through and make the necessary suggestion, contribution and correction. According to Cohen, Manion, and Morrison (2007), assumptions about validity in interviews are based on face validity, and they are drawn far too frequently. That is, it appears that the interview questions are measuring what they purport to measure. One cause of invalidity is bias and the most practical way of achieving greater validity in interviews is to minimize the amount of bias as much as possible. The researcher ensured this by giving the same set of questions to all respondents. The face validity of the interview questions was also determined by the researcher's supervisor and three teachers in the integrated science department of the school where the study was conducted.

3.7 Reliability of instrument

Reliability is the ability of a research instrument to provide similar results when used repeatedly under similar conditions. Reliability indicates the accuracy, stability, and predictability of a research instrument: the higher the reliability, the higher the accuracy; or the higher the accuracy of an instrument, the higher its reliability (Kumar, 2011). According to Taale and Ngman-Wara, (2003), the reliability of a research instrument is the degree to which the instrument scores are free from measurement errors, and are consistent from one occasion to another when the instrument is used with the target group. Reliability is the degree of consistency of the research instrument, that is, the degree to which the results produced by the instruments are the same when the same tasks are completed on the same or different occasions or different but equivalent tasks are completed on the same or different occasions (Dzakadzie, 2017). To determine the consistency of the test results, the test-retest method, which involves the stability of scores over some time or measuring the same object or phenomenon more than once, using the same technique or instrument (Eshun & Effrim, 2014) was used. That is, the same group of students used in determining the validity was used. The test was administered and re-administered within a week interval to produce a high-reliability coefficient since a longer interval can result in fading of ideas. The results of both trials were analyzed for the reliability coefficient. A Cronbach alpha coefficient above 0.80 and 0.90 inclusive is considered appropriate (De Villiers, 1991). A Cronbach alpha coefficient of 0.98 was obtained from the analysis. The researcher and a few other teachers in the department of Integrated science initially performed the activities and experiments listed in the lesson notes to ensure accurate and consistent results before it was done by the students in the class.

3.8 Data Collection Procedure

The researcher issued an introductory letter from the department of study to the school where the research was conducted, seeking the permission of the school administrators to carry out the collection of data on the research work. The administration and the collection of the instruments were carried out by the researcher with the assistance of some assigned Integrated Science teachers by the head of science departments. Participants selected for the study were taught the Integrated Science concepts using the Conceptual Change Model and through that their misconceptions were detected using Students Misconception Diagnostic Test (SMDT) and at the same time remediated through the intervention process. In the course of each CCM lesson, students were given a set of oral questions to check if they have understood the concept and the specific objectives of each lesson is being acheieved. At the end of one month of experimental teaching periods, Science Performance Test (SPT) or post-test was administered to the students to determine the effectiveness of the intervention (CCM) by comparing the result of their pre-tests **(SMDTs)** and their post-test **(SPT)**. An interview was also conducted after the intervention to identify their perception of the use of CCM as a teaching strategy in remediating their misconceptions. The information received was collated using a voice recorder and later they were organized and analyzed based on the research objectives.

Intervention process

The Senior High School Teaching Syllabus for Integrated Science (2010) served as a guide for the researcher to create a weekly lesson plan for five lessons (Appendices A 1, A 2, A 3, A 4 and A 5). The Conceptual Change Model (CCM) procedure, developed by Schmidt et al. (2006), was modified by the researcher to include group discussions and practical exercises in the development and instruction of each CCM lesson.

The goal of the intervention process was to address students' misconceptions regarding force, motion, and pressure. Three conceptual units were formed from the five CCM lessons that were taught. The CCM force concept was the first unit. The CCM motion concept was the second unit. The CCM pressure concept comprised the third unit. Two lessons covering the definition of force, several types of force, the Archimedes principle, and the law of floatation make up the CCM force concept. Two lessons on concepts related to motion, inertia, momentum, the centre of gravity, and object stability was included in the CCM motion concept. The third unit of the CCM included a lesson on the definition of pressure and how it affects solids, liquids, and gases.

The conceptual change model lesson contains six phases or steps (Schmidt et al., 2006). The first step was to conduct a diagnosis on the students to determine whether they have any misconceptions. The Students Misconceptions Diagnostic Test (SMDT), was utilized by the researcher to complete the first step of the process. The total scores for the SMDT (Appendix B) were 30 after the conclusion of the five lessons, with 12 marks on the CCM force concept, 11 marks on the CCM motion concept, and seven marks on the CCM pressure concept. Students whose total marks was 15 and above at the end of the five SMDT were considered pass. While 15 were considered fail.

Students share their beliefs and why they chose the answers they have chosen with their peers in the second part of the CCM process so that they may observe the variations in beliefs (Schmidt et al., 2006). Following the test, the students were divided into eight groups of five each in each class. These questions (SMDT) were addressed within each group, and each group member's responses were shared with the other groups in order for everyone in the class to be aware of the preconceptions of their group members regarding the topic at hand. This was important because it makes each student accept the proper scientific concept after the treatment. Providing students with constructivist-based activities to challenge their preconceptions is the third step of the CCM lesson (Schmidt et al., 2006). The researcher subsequently created a list of activities or investigations that addressed these misconceptions in each lesson as depicted in the various lesson plans. These activities pushed their preconceived notions of the concepts and assisted them in adapting to the more recent and accurate scientific ideas.

According to the CCM lesson's fourth step, students should be free to reorganize their previous ideas and adopt new ones (Schmidt et al., 2006). This was verified in each lesson by the researcher going over the students' prior understanding of each lesson. Additionally, students were given the opportunity to ask questions about concepts that challenged their prior understanding during lessons in order to gain further clarification, students were given the chance to connect their new knowledge to prior knowledge by answering questions (evaluation) during the learning process.

Students are required to test out their recently developed mental schema in novel settings and circumstances in the fifth and sixth steps of the Conceptual Change Model Lesson (Schmidt, Saigo, & Stepans, 2006). By structuring all of the SMDT questions to cover all five lessons covered by the Conceptual Change Model approach, the researcher gave students the chance to test their newly established mental model in unique situations. The researcher referred to this test as the Science Performance Test (Appendix C). The intervention phase was implemented over the course of four weeks, and following the experimental teaching period of four weeks, the Science Performance Test (SPT) which comprised of objective test items (MCQ and short-answer questions) that have been chosen from the pre-tests (SMDT) were administered to students. The scripts were graded, and the findings were compared to the SMDT scores of the students to conduct analysis. The 20 MCQ has four answers. There was one correct response among the choices, and three logical alternatives (incorrect answers).

These reasonable false replies were regarded as misconceptions. Equal weight was given to each question. Each accurate response selected for an MCQ question in section A received one mark, for a final score of 20. Additionally, each short answer question was worth two marks, for a total of ten marks. A total of 30 marks were given for the science performance test. The purpose of this was to evaluate whether there had been any significant differences between pre- (SMDT) and post- (SPT) test in order to assess the success of the conceptual change model as an intervention.

After finishing the entire procedure, the researcher conducted an interview with students to learn their opinions on the Conceptual Change Model as a teaching approach and how it helped correct their misconceptions. Due to the time constraint, a student from each group from the two classes (N=16) were chosen for the interview. The responses were recorded, organised and subjected to content analysis.

3.9 Lesson presentation on force, motion and pressure

LESSON 1

Class: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: FORCE

Relevant Previous Knowledge: Students have an idea of the meaning of force and some types of forces.

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

1. explain the meaning of force
2. list the various types of forces
3. state the effect of force on an object

Teaching and Learning Materials:

Table, elastic string, book, and stones

Teacher-Learner Activities

Introduction: The researcher begins by identifying the students' preconceptions about the topic using the SMDT in the lesson. Following the test, the researcher divided the students into five groups and asked them to discuss their understanding of the questions among themselves. At the conclusion of the discussion, it was discovered that students have misconceptions about force, types of force, and the effect of force on objects. The researcher used the following activities to address the students' misconceptions about the aforementioned topic:

Activity one: The researcher brainstorms with students to bring out the meaning of force by placing a book on top of a table and asking the students to identify the type of force acting on it when at rest. Answers such as *"normal reaction force, gravitational force, and frictional force"* were obtained from students.

Activity two: The researcher asked one of the students to push and pull the book on the table. The students observed the book on the table being pushed and pulled, and the researcher then asked them to identify the type of force that causes the book to move when pushed or pulled. The students stated that the book moves as a result of the force exerted by the student who pulled and pushed it.

The researcher also asked the students what kind of force would keep the book from moving if the applied force was less. "*It's the frictional force,"* said the students. The researcher praised them and went on to explain that friction is determined by the nature of the two surfaces in contact as well as the degree to which they are pressed together. The formula $Ffrict = \mu \times Fnorm$ can be used to calculate the maximum amount of friction force that a surface can exert on an object. Where μ is the friction coefficient and Fnorm is the normal reaction force. The researcher then asked some students to define force by observing the book at rest on the table and when it was pulled and pushed by the student. All of the students who were called defined force as the *"pull or push of an object."* The researcher then modified this definition to include an object's pull or push that causes the object's state to change. The researcher went on to explain that the forces acting on the book when it was at rest on the table were gravity and normal reaction forces, not friction.

Activity three: The researcher submerged a cork in water and let it go. The cork resurfaces on the water, and the researcher asks the students to explain what force caused it to do so. "*The cork resurfaces as a result of an upward force in the water exerted on the cork," students explained. And that force is referred to as upthrust.* " The researcher praised their responses and went on to explain that the upthrust force of the object immersed in the fluid is equal to the weight of the fluid displaced by the object. The researcher also stated that if the weight of the fluid displaced is greater than or equal to the weight of the object immersed, the object will float, whereas if the weight of the fluid displaced is less than the weight of the object, the object will sink.

The researcher then asked the students to describe the type of force that exists between the cork and the water flowing past it in a direction that opposes the flow of water past the cork. Some students mentioned frictional force, while others mentioned viscosity or viscous force. According to the researcher, "*viscosity is the correct force that exists between the cork and the water that tends to oppose the flow of the water past the cork and is often referred to as fluid friction."*

Activity four: The researcher launches a duster vertically into the air and lets it fall freely to the ground. The researcher asked the students to identify the type of force responsible for the duster falling freely to the ground. Students provided answers such as "gravitational force, the force of gravity." The researcher was pleased with their responses and explained the distinction between these two forces as follows:

The gravitational force is the force that attracts another object to the earth, moon, or other massively large objects. Thus, it acts between any two objects with mass that are separated by a distance. The force of gravity is responsible for returning items thrown into the air to the Earth. The force of gravity on Earth is always equal to the object's weight, as determined by the equation Fgrav = m g, where m is the object's mass and g is the acceleration due to gravity.

Activity five: The researcher asked one of the students to send a magnet close to a magnetic material (a nail). The nail was drawn in by the magnet. The researcher asked the entire class to identify the type of force used by the magnet to attract the nail. The students responded, "*The magnetic force.*" The researcher was pleased with their response and asked one of the students to use the demonstration to define magnetic force. "*Magnetic force is defined as the force exerted by a magnet on magnetic objects (such as a nail).*" According to the student, the definition was agreed upon by the entire class, and the researcher added that magnetic force is an example of a non-contact force that exists when two objects are not in contact.

Activity six: Two students were summoned by the researcher to stretch a rope. The researcher asked the students to identify the type of force transmitted by the rope. According to the students, "*tension force is transmitted through the rope.*" The researcher thanked them and explained further that tension force is the force transmitted through a string, rope, cable, or wire when it is pulled tight by forces acting from opposite ends. The tension force is directed along the length of the rope and pulls equally on the objects at each end.

Following the explanation, the researcher asked the students to discuss how they might encounter various types of forces in their environment. Answers such as "*using a magnet to pick up office pins from the ground aids in experiencing magnetic force" When walking on a rough road, a frictional force is felt. Placing a cork in water and releasing it aids in experiencing upthrust force. Because of normal reaction force, we* *can feel our weight. We are not floating on Earth due to gravitational force or the force of gravity,'* students stated.

Activity seven: The researcher summons two students and instructs them to grasp the ends of an elastic string. The researcher instructed the entire class to observe the elastic string's original length. The researcher instructed the two students to stretch the elastic string and asked the students to make observations about the elastic string as it was stretched. Students responded that when stretched, the elastic string expands in length or size. The researcher praised their responses and concluded that stretching the elastic string is a method of applying force to the elastic string, and this force causes the string's size to change. As a result, one example of how forces affect objects is that "a force can change the size of an object. After that, the researcher asked students to describe activities that demonstrate the effect of forces on objects. Students provided the following responses:

1. Kicking a ball at rest causes it to move. As a result, a force can cause a still body to move.
2. Changing the speed of a car by pressing the accelerator means that a force can change the speed of a moving object.
3. Stepping on the brake of a moving car causes it to come to a complete stop. As a result, a force can cause a moving object to come to a stop. The researcher concluded the lesson by giving students the opportunity to ask questions about the concept that challenged their prior knowledge or assumptions and assisted them in addressing them.

Evaluation

1. Identify the forces that act on a book at rest?

Students' responses: *'normal reaction force, gravitational force, and frictional force.*

2. Identify the type of force that will cause the book to move when pull or push

Students' response: *the force applied*

3. Define force

Students' response: a force is defined as a "*pull or push of an object.*

4. Explain the type of force that causes a cork placed in water to resurface.

Students' response: *"The cork resurfaces as a result of an upward force in the water exerted on the cork, and that force is referred to as upthrust.*

5. Discuss how you might encounter various types of forces in your environment.

Students' responses: *"using a magnet to pick up office pins from the ground aids in experiencing magnetic force" When walking on a rough road, a frictional force is felt. Placing a cork in water and releasing it aids in experiencing upthrust force. Because of normal reaction force, we can feel our weight. We are not floating on Earth due to gravitational force or force of gravity,*

6. What is the effect of force on an elastic string?

Students' response: *a force changes the size or length of an elastic string*

7. Describe an activity that demonstrate the effect of forces on objects.

Students' responses: Kicking a ball at rest causes it to move. Changing the speed of a car by pressing the accelerator. Stepping on the brake of a moving car causes it to come to a complete stop.

LESSON 2

Class: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: FORCE

Relevant Previous Knowledge: students have pulled or pushed an object to explain the meaning of force. Students have ideas on the types and effects of forces.

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

1. state the Archimedes principle and law of flotation
2. explain some phenomenon using Archimedes principle and law of floatation.

Teaching and Learning Materials:

Water in a bowl, wooden objects, metallic objects

Teacher- Learner Activities

Introduction: The researcher examines the students' pertinent prior knowledge. By giving the SMDT during the lesson, the researcher diagnoses students' misconceptions of the concept. The researcher then instructs students to debate their responses with their group members in order to determine the many perspectives that students bring to the science classroom.

Activity one: The researcher filled a beaker with water to the 200 cm^3 mark while the students watched, and then called one student to gently lower the wood using the thread into the beaker. The researcher then asked students their observations about the demonstration, and students responded that "*the volume of the water has increased from 200 cm^3 to 240 cm^3*." The researcher then asked the students their understanding of this. Answers like "*it's because the wood has some weight, the 40 cm^3 that has been added is the volume of the wood, and the upthrust in the water has exerted on the wood*." Were obtained from students. The researcher then praised their answers and supported their assertion that an object immersed in a fluid (liquid or gas) experiences an upward push force (upthrust) equal to the weight of the fluid displaced. The weight of the fluid displaced can be calculated from the formula **W = p ×v × g** Where p is the density of the water, v is the volume of water displaced and g is the acceleration due to gravity. Since the fluid used was water, the density of the water is $1gcm^{-3}$ ($1000\ kgm^{-3}$), the volume of water displaced is $40\ cm^3$ ($40\times10^{-6}m^3$), and acceleration due to gravity is approximately $10ms^{-2}$. Therefore, the weight of water displaced $W = 1000\times40\times10^{-6}\times 10$ = **0.4N**. The upward force that the water applied to the wood is equal to the weight of the fluid that was displaced. It is often referred to as the Archimedes principle. According to Archimedes' principle, a body immersed completely or partially in a fluid will experience an upthrust equal to the weight of the fluid displaced.

Activity two: A cork and a metallic object (a 10-pesewa coin) were placed in water, and the researcher asked the students to observe and comment. The students reported that the cork floats while the metallic object (the coin) sinks in the water. The researcher demanded their explanation for why the cork was floating and the coin sank. Responses like "*This is because the coin is heavier than the cork; the coin has a bigger density than the water, but the cork has a smaller density; the cork floats because it can displace an amount of water equal to its weight, unlike the coin, which can only displace a small amount of water.*" were given by students. The researcher appreciated their comments and concluded that anything they had to say could influence whether an object floats or sinks. But the fundamental idea underpinning floatation is that an object must displace a weight of water equal to its own weight in order to float. The object will sink if it cannot displace the weight of water or any other fluid that is larger than or equal to its weight. When the scenario was described, the researcher then called one of the students to explain the law of flotation. The student replied that "*a floating body* *displaces its own weight in the fluid in which it floats,"* according to the concept of floatation.

Activity three: One of the students was called upon by the researcher to place a fresh egg in freshwater, and the students were instructed to watch what happened. The student was then instructed to take the egg out of the fresh water and deposit it in a concentrated salt solution by the researcher. The researcher requested from the students an explanation of each observation. the students answered that, "*the fresh egg placed in the freshwater sinks but the same egg floats when placed in a concentrated salt solution."* The researcher commended them and went on to explain to the students that salt solution is denser than freshwater because it includes salt solute. Because seawater has a higher density than freshwater, it produces a greater upthrust (weight displacement). Unlike freshwater, which has a comparatively modest upthrust because of its low density. As a result, the egg sinks in freshwater but floats in seawater.

Activity three: The researcher asked the students to discuss the issue, "Why do boats float in water?"

The students talked about how a boat is built with a lot of surface area at the bottom to displace a lot of water. "*The boat floats on water because the weight of the water it displaces is equal to its own weight*." Additionally, "*it contains a sizable core cavity that is air-filled, giving it a big volume and lowering its density. The boat floats because the density of air is lower than the density of water*." The conclusion is that "*the boat floats because it displaces water that weighs more than or equal to its own weight."* The researcher concluded the lesson by giving students the chance to ask questions about the idea that test their prior understanding or presumptions and assisted them in addressing it.

Evaluation

1. What causes the volume of water to increase when a wooden object is placed into it?

Students' response: it's because the wood has some weight, the volume added is the volume of the wood, the upthrust in the water has been exerted on the wood."

2. Why does a cork float in water but a coin sink in water?

Students' response: this is because the coin is heavier than the cork, the coin has a bigger density than the water but the cork has a smaller density, the cork floats because it can displace an amount of water equal to its weight, unlike the coin which can only displace a small amount of water.

3. State the principle of floatation

Students' response: A floating body displaces its own weight in a fluid in which it floats.

4. Why do boat floats in water?

Students' responses: The boat floats on water because the weight of the water it displaces is equal to its own weight. The boat floats because the density of air is lower than the density of water. The boat floats because it displaces water that weighs more than or equal to its own weight.

LESSON 3

Class: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: MOTION

Relevant Previous Knowledge: students have ideas on motion and types of motion.

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

1. explain the terms distance, displacement, speed, velocity, acceleration,
2. distinguish between the term inertia and momentum
3. Express the relationship between these terms listed in one and two above.

Teaching and Learning Materials:

Table, marker board illustration

Learners' Activities

Introduction: The researcher administered the SMDT in the lesson to students to diagnose their misconceptions about the CCM motion concept. The researcher collected the scripts and instructed students to discuss the questions and their answers with their group members so that there would be familiarity when devising ideas in the classroom. The researcher reviewed the relevant prior knowledge of the students on motion and types of motion by asking them simple questions.

Activity one: the researcher brainstorms with students to bring out the meaning of the following terms: distance, displacement, speed, velocity, and acceleration.

The researcher asked a student to walk from one side of the class to the other. The researcher explains to students that the interval between where the student started walking and where she is currently standing is the distance the student has covered. The researcher used this same demonstration to explain displacement as the change of position from the student's initial position to its final position or the distance she covered in the east direction of the class. The researcher further explains to them that how fast the student changes its position or covers that interval is known as its velocity or speed. The researcher also explains to the students that the time of change of the speed or velocity is its acceleration. The researcher asked the students to use the explanation above to define the following terms: distance, displacement, speed, velocity, and acceleration. The students answered that "distance is the magnitude of displacement or the interval between two points. Displacement is the distance travelled by a body in a specific direction or the position of a body relative to its origin. Speed is the rate of change in distance. Velocity is the rate of change in displacement. Acceleration: This is the rate of change in velocity.

Activity two: The researcher explained inertia and momentum to the students. According to the researcher, the tendency of an object to move (slowly or rapidly) and to stop moving can be affected by its mass; this property is known as inertia. How simple or complex it is to change an object's motion is determined by the inertia of the body. The only factor affecting an object's inertia is its mass; hence, the kilogram (kg) is the unit of inertia. This implies that inertia increases with mass and vice versa. The body's momentum is defined as the product of its mass and velocity. After the explanation, the researcher called a few students over to explain the difference between momentum and inertia. The students responded, "Momentum is the product of a body's mass and velocity, while inertia is the resistance of a body to move when at rest and to stop when moving with uniform velocity in a straight line." The researcher commended them and asked them to discuss the significance of using a seatbelt in a moving vehicle. The students said in response that "*when a passenger in a car refuses to wear a seatbelt and there is a sudden brake or a sharp turn of the car, it poses a force that overcomes the passenger's inertia and changes the momentum of the passenger, which throws the* *passenger forward. It may cause the passenger to hit the head or body against objects in front or throw the passenger out of the vehicle through the windscreen when he refuses to wear a seatbelt."*

Activity three: The researcher then assisted them in solving problems in order to improve their understanding. The researcher asked students to give the mathematical formulas for speed, velocity, acceleration, and momentum. The following answers were given by students: Speed is calculated as distance travelled / time. Velocity = displacement/time taken. Acceleration = change in velocity / time, and momentum =mass × velocity.

The researcher wrote the question on the board for students to solve to test their understanding.

i. "Find the momentum of a body of mass 1000kg moving at a speed of 20ms^{-1}.

ii. if the speed of the body changes to 40ms^{-1} in 2s, calculate its average acceleration.

Students solve the question correctly by using the formula i. momentum = $mass \times velocity$. Momentum = 1000 × 20, Momentum = 20,000kgms^{-1}.

ii. acceleration = change in velocity / time, a = (v- u) / t, a = (40-20) / 2, a = 10ms^{-2}. The researcher appreciated them and then brought the lesson to an end, and by offering students the option to ask questions about the idea that test their prior understanding or presumptions and assist them in addressing it, the researcher concluded the lesson.

Evaluation

1. distinguish between the following terms;

   a. distance and displacement b. speed and velocity c. inertia and momentum

Students response: *distance* is the magnitude of displacement or the interval between two points. While *displacement* is the distance travelled by a body in a specific direction or the position of a body relative to its origin.

speed is the rate of change in distance. Mathematically, speed distance travelled / time. While *velocity* is the rate of change of displacement. Mathematically, velocity = displacement/time.

Inertia is the reluctance of a body to move when at rest and to stop when moving with uniform velocity in a straight line. Or it is the tendency of a body to remain in its state of rest or in its uniform motion while *Momentum* is the product of the mass of a body and its velocity. Mathematically, momentum = mass ×velocity

2. Defined acceleration

Students response: Acceleration is the rate of change of velocity. Mathematically, acceleration = change in velocity / time, a = (v- u) / t

i. Find the momentum of a body of mass 1000kg moving at a speed of $20ms^{-1}$.

ii. if the speed of the body changes to $40ms^{-1}$ in 2s, calculate its average acceleration.

Students response: i. momentum $= mass \times velocity.$

Momentum = 1000×20

Momentum = $20{,}000kgms^{-1}$

ii. acceleration $= (change\ in\ velocity)/(time\ taken)$. $a = (v - u)/t$

a = $(40 - 20)/2$ = $20/2$ = $10ms^{-2}$

3. Why is it important to wear seat belt when you are in a moving vehicle?

Students response: the sudden brake and the sharp turning of the vehicle poses a force, which overcomes the ***inertia*** of the passengers. Therefore, the change in ***momentum*** throws the passenger forward. In extreme cases, it may cause the passengers to hit their heads or bodies against objects in front of them or throw them out of the vehicle through the windscreen.

LESSON 4

Class: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: MOTION

Relevant Previous Knowledge: students have ideas on Centre of gravity and stability.

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

1. define Centre of gravity
2. Explain the meaning of equilibrium
3. distinguish between stable, unstable, and neutral equilibrium

Teaching and Learning Materials:

Table, three cones

Learners' Activities

Introduction: On the fourth lesson, the researcher gives students the SMDT to assess their understanding of CCM motion concept 2. The researcher gathered the scripts and gave the students instructions to discuss the questions and their responses with their members. In order to prepare students for the intervention, a discussion was held in order to help them recognise the variety of ideas that their own peers bring to the science classroom.

Activity one: The researcher asked one of the students to balance a 100-centimetre ruler on the knife edge by placing it there and adjusting it until it was balanced. A few students from each group were invited by the researcher to see the spot on the metre rule where it is balanced. Students noted that "*the ruler was balanced on the knife edge at the 50-cm mark.*" The researcher revealed to the students that the metre rule's centre of gravity (50 cm) is where its weight is concentrated. This point is where the rule is balanced on the knife edge. The researcher then called on one student to define the centre of gravity of an object. The student responded that "*the centre of gravity of an object is the point on the object where the total weight of that object acts."* The researcher praised them and moved on to the next activity.

Activity two: The researcher offered three cones to three students, asking them to place one on a table with its base, one with its apex, and the final cone with its side. The researcher instructed them to push their cone just a little while asking the rest of the class to watch and comment on what happened. "The cone with its bases on the table returned to its former position following the slight push; the cone with the apex dropped off and was unable to get back into its original place, whereas the cone with its side on the table rolled out of its regular position and remained at rest," the students who had been watching noted. The researcher asked the students about the reasons behind these findings. The majority of students were able to explain the cones at the base and the apex using the concept of the centre of gravity, but no student was able to explain the cone at the side. The majority of students said, "With the cone at the base, the centre of gravity is discovered at its lowest position, and the base of the cone is broad relative to the apex, which causes it to return to its original position after a slight push. However, the cone's apex on the table gives it a smaller base, and its raised centre of gravity causes it to fall off after a litter push. The researcher praised them and went on to further explain that the three types of equilibrium are explained by the placement of the three cones. The cone displays a steady equilibrium with its base on the table. Instable equilibrium is represented by the cone's apex on the table, while neutral equilibrium is represented by the cone's side on the table. The cone is in neutral balance because its centre of gravity, following displacement, stays at the same height. The researcher used the example of a ball rolling to further clarify neutral equilibrium for the students. A ball's centre of gravity does not change when it is rolled. As a result, the cone on its side and the ball are said to be in neutral equilibrium. The researcher then called a few students over to explain the differences between stable, unstable, and neutral equilibrium. The students responded, "*A system is said to be in stable equilibrium if, upon being displaced from the equilibrium state, it returns to its original position in the direction opposite to the displacement. If a system accelerates away from its equilibrium position after a small displacement, it is said to be in an unstable equilibrium. If a system's equilibrium is unaffected by deviations from its initial state, it is said to be in neutral equilibrium."*

Activity three: Students were challenged to use their knowledge of stability and equilibrium to explain why it is not a good idea to overload a vehicle's top carrier. The students' response was that when a vehicle is loaded heavily at the top, the centre of gravity will be raised, resulting in the vehicle being unstable or in an unstable equilibrium. A couple will cause the car to tip over onto its side if it is slanted. And as a result, it may quickly collapse. However, when a vehicle is carried onto a base carrier, its centre of gravity will be at its lowest point, and it will be in a stable equilibrium state. Even if the car is tilted, it will settle back into place. The researcher expressed appreciation for them, gave them the opportunity to raise questions that challenged their past beliefs or presumptions, and assisted them in addressing them as the researcher wrapped up the lesson.

Evaluation

1. Distinguish between the three types of equilibrium

Students' response: Stable equilibrium: A system is said to be in stable equilibrium if, when displaced from the equilibrium position, it experiences a net force or torque in a direction opposite to the direction of the displacement.

Unstable equilibrium: A system is in unstable equilibrium if, when displaced, it experiences a net force or torque in the *same* direction as the displacement from equilibrium. A system in unstable equilibrium accelerates away from its equilibrium position if displaced even slightly.

Neutral equilibrium**:** A system is in neutral equilibrium if its equilibrium is independent of displacements from its original position.

2. Why is it dangerous to load the top carriers of vehicles heavy?

Students' response: vehicles that load their top carriers heavy will easily topple over. This is because when a vehicle is loaded heavily at the top, the **Centre of gravity** will be raised. The vehicle now become unstable or is in the condition of ***unstable equilibrium***. If the vehicle is tilted, a couple will make it turn over onto its side. And this can make it easily topple over.

LESSON 5 **Class**: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: PRESSURE

Relevant Previous Knowledge: students have previous knowledge on force and effect of force on the objects.

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

1. define pressure
2. perform simple calculation on pressure
3. describe the effects and application of pressure in solids, liquids and gases

Teaching and Learning Materials:

Rectangular block of wood, a tall container with three holes at different heights, bicycle pump, water

Teacher- Learners' Activities

Introduction: The researcher gave the students a series of questions (SMDT) at the start of the lesson to assess their understanding of the CCM pressure concept. The researcher then discussed with the students the test results.

Activity one: The researcher asked students to explain what pressure meant. The majority of students were able to state the mathematical formula for pressure, which is the force on area, and define pressure as the force per unit area of a substance. The majority of students correctly anticipated that pressure is measured in pascals or Newtons per square metre when the researcher asked them to state the unit of pressure. The researcher asked students to list the factors influencing solid pressure. According to the students, "the magnitude of the force and the area in contact with the solid" are the factors that influence pressure in solids. The researcher thanked them and went on to explain that the force's magnitude is directly proportionate to the pressure. This implies that pressure increases with an increase in force and vice versa. Additionally, the relationship between pressure and the area of contact is inverse. This means that a smaller area will result in high pressure. By posting a series of questions on the board, the researcher helps students calculate the pressure of some substances using the formula.

Activity two: At the water tap, the researcher set up a tall container with three holes at various heights. Students' observations were solicited by the researcher. The students' response was that the water is coming from the bottom hole at a faster rate than it is coming from the middle and top holes. The researcher commended them and told them that depth causes pressure to increase. Liquid depth, density, and the acceleration due to gravity pushing on the liquid's surface are multiplied to create pressure in liquids. P is pressure, p is the liquid's density, g is the acceleration due to gravity, and h is the liquid's depth; therefore, P = pgh. All these factors are directly proportional to the pressure, where acceleration due to gravity acting on the surface of the liquid is constant. This means that pressure increases with the depth of the liquid and the density of the liquid.

Activity three: One student was requested to raise a bicycle pump's piston at the researcher's request. The pump's piston was raised and lowered by the learner. Students were given an explanation by the researcher of what happens when the piston of a bicycle pump is raised and lowered, explaining that, doing so creates a space inside the pump for air molecules to enter. Air began to fill the piston. The air was compressed and propelled into the bicycle tyre when the piston was pulled down. This causes the bicycle to inflate. Students were asked to describe the purpose of making cutting and piecing tools sharp. In response, the student stated, "*Cutting and piercing tools are made sharp to limit the surface area of the cutting or piercing edge so that the least force applied to the tool will have a high pressure to facilitate its cutting or piercing. or "cutting tools," such as knives, are sharpened to reduce the area over which the force being applied increases pressure and facilitate cutting since pressure increases with decreasing area*." The researcher then gave students the chance to raise questions about the lesson that challenged their existing knowledge or preconceptions and assisted them in addressing them as she completed the class.

Evaluation (Students Achievement questions)

1. Define pressure.

Students response: pressure is the force per unit area of a substance.

2. Give reasons why cutting and piercing tools are made sharp.

Students response: they are made sharp so as to have a greater pressure at the edge of the tool even for a small applied force, to make its cutting or piercing action sharp and quick.

3. A regular concrete block weight 5kg has an area of 0.016m^2. calculate the pressure the block will exert on the ground. [g = 10ms^{-2}].

Students response: pressure = force / area.

Force (weight of the block) = mass × acceleration due to gravity

F = 5× 10 = 50N.

Pressure P, = 50 / 0.016

P = 3125pascals

3.10 Data Analysis

This study employed both qualitative and quantitative methods (mixed method approach) in analyzing the data that was collected. According to Creswell (2014), a mixed method is an approach to an inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone (Creswell, 2014). The data from the lesson plan (the various SMDTs) were analysed by statistical parameters such as frequencies and percentages. Also, the SMDT and SPT were together analysed quantitatively using the Statistical Package for Social Sciences (SPSS) and Microsoft excel spreadsheet to present descriptive statistics of the data such as mean and standard deviation and also inferential statistics such as t-Test. The t-Test was used to investigate whether any differences existed between students' mean scores on the SMDT and SPT. The qualitative data analysis was done through qualitative discussion (content analysis).

The process of summarizing and reporting the primary contents of data and their messages is known as content analysis (Cohen, Manison, & Morrison 2007). This was done to investigate the descriptive information obtained from students' perceptions of using the conceptual change model as an intervention. Table 1 shows the analysis framework for the study.

Table 1- Framework of Data Analysis

Research questions	Nature	Unit of analysis	Statistical tool (s)
1	Quantitative	Students Misconception Diagnostic Test (SMDT)	Frequency, percentages
2	Quantitative	Science Performance Test (SPT) and SMDT	t-test, Mean, standard deviation
3	Qualitative	Interview	Qualitative discussion

3.11 Ethical Consideration

To gain access to the students in the selected school, permission was obtained from the school head. In this regard, a letter was written explaining the purpose of the study and why the data was needed from the students. Permission was subsequently granted for data to be collected. Furthermore, the researcher explained the purpose of the study to the participants and assured them of anonymity and confidentiality of the information that was given.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The Student Misconception Diagnostic Test (SMDT), the Student Achievement Questions (SAQ), the Science Performance Test (SPT), and the interview on students' perceptions of the use of the Conceptual Change Model (CCM) as an intervention to correct their misconceptions on force, motion, and pressure were all examined in this chapter. This chapter includes a thorough discussion of the research questions that were addressed in the study.

4.1 SMDT item-by-item results discussion on force, motion and pressure (Appendix B)

Item 1

In item one, students were required to apply their knowledge of the effect of force on objects. A force is an object's pull or push. Alternatively, force is defined as anything that alters the state of an object at rest or in uniform motion in a straight line. As a result, when a force is applied to an object, it can change its speed, shape, volume, and direction, but its mass remains constant. Option D is thus the correct answer. The incorrect responses were interpreted as students' misconceptions about item 1. Incorrect responses were given by 11 (13.7%) students, claiming that a force cannot change the speed of a body's motion. Furthermore, 16.0% of students believe that a force cannot change the shape of the body. In addition, 12 (15.0%) students incorrectly stated that when force is applied, the direction of motion of the body does not change. Only 41 (51.3%) of the 80 students correctly believed that a force cannot change the mass of a body but can change its speed, shape, and direction. No student (0.0%) was unable to select an answer to this item. It appears from the results that:

1. Approximately 49% of the students expressed the misconception that applying force to a body could change its mass.
2. The remaining 51% of the students expressed the correct conception that a force can change the shape, speed, and direction of a body but not its mass.

Table 2 shows students' results to item 1.

Table 2: Students' pattern of responses to item 1 (N = 80

Options	Frequency (N)	Percentage (%)
A	11	13.7
B	16	20.0
C	12	15.0
D	41	51.3
No response	0.0	0.0

Item 2

This item sought to ascertain students' perceptions of how a weightless object in space feels. This item requires students to apply their knowledge of the type of force (the normal reaction force) that interacts with an object's weight (the force of gravity) to assist it in feeling its weight. The sensation of weightlessness occurs when there are no contact forces (e.g., normal reaction forces) to counteract a person's weight. It occurs when gravity is the only force present and the apparent force (normal reaction force) is absent, and the body's weight exactly balances the force of gravity. On Earth, the force of gravity is always equal to the weight of the object, as determined by the equation F(grav) = mass *acceleration due to gravity. As a result, option D is the correct response. It was incorrectly answered by 13 (16.3%) students that an object in space is weightless because the object is close to the sun, and thus the acceleration due to gravity balances that of the sun. Fourteen (17.5%) students believed that because there is no air in space to influence the weight of an object, the object would be weightless. Eighteen (22.5%) students incorrectly stated that because there is no force of gravity in space, objects in space feel weightless. However, 35 (43.7%) students demonstrated strong comprehension by stating that objects appear weightless in space because their weight precisely balances the force of gravity. 0.0% of students do not respond to the item. It appears from the results that:

1. The majority of students (56.3%) expressed the misconception that objects in space appeared to be weightless because there is no air, no gravitational force, and the acceleration caused by the gravity of the earth equals that of the sun.
2. A small majority of students (43.7%) expressed the correct conception that because an object's weight balances the force of gravity, it appears to be weightless in space. Table 3 depicts students' results to item 2.

Table 3: Students' pattern of responses to item 2

Options	Frequency (N)	Percentage (%)
A	13	16.3
B	14	17.5
C	18	22.5
D	35	43.7
No response	0	0.0

Item 3

Students were asked to answer this question using the concept of the type of force (frictional force) and the laws of friction. They were to apply the concept of frictional force, which is a type of force that tends to prevent or slow the motion of two or more bodies sliding over each other. Friction force frequently opposes an object's motion and is determined by the nature of the two surfaces and the degree to which they are pressed together. The explanation for this type of force suggests that option C is the correct response to this item. Out of the eighty students who answered this item, 21 (26.3%) of the students agreed that the area of the surface in contact influences the frictional force between two bodies. Furthermore, 18 (22.5%) students believe that the frictional force between two bodies in contact is proportional to the speed at which the bodies are moving. Only 31 (38.7%) of the total number of students correctly answered that the frictional force between two bodies depends on the nature of the surfaces in contact. However, 10 (12.5%) students believed that frictional force was determined by the moment of the bodies in contact. None of the students were unable to select an option. It appears from the responses that:

1. The majority of students (61.3%) voiced the misunderstanding that the area, speed, and moment of the bodies in contact determined the frictional force between them.
2. Only 38.7% of students correctly stated that the nature of the two surfaces in contact affects the frictional force. Table 4 depicts students' responses to item 3.

Table 4: Students' pattern of responses to item 3

Options	Frequency (N)	Percentage (%)
A	21	26.3
B	18	22.5
C	31	38.7
D	10	12.5
No response	0.0	0.0

Item 4

Item 4 also requires students understanding on the different types of forces as well as the Archimedes principle, which states that when a body is immersed entirely or partially in a fluid (liquid or gas), it experiences an upthrust (an upward force in fluid) equal to the weight of the fluid displaced. Thus, upthrust is the upward force exerted by a fluid, and it is the type of force that brings an object back to the surface of the water when immersed in it. As a result, the balloon was able to resurface on the water's surface because the upthrust acting on it was equal to its weight. Twenty-two (27.5%) students responded that tension force was the type of force that works on an object when it is submerged in water to bring it back to the surface. Furthermore, 9 (11.3%) students incorrectly stated that frictional force is the type of force that acts on a body immersed in water. 38 (47.5%) students correctly responded that upthrust force is the type of force that acts on an object (e.g., a balloon) to bring it back to the surface after being pushed into the water and released. Furthermore, 11 (13.7%) students incorrectly predicted that gravity would cause the balloon to return to the surface. No student fails to express their thoughts about the item. It appears from the results that:

1. The misunderstanding that friction, tension, and gravity are the sorts of forces that act on an item submerged in a fluid (such as water) was expressed by almost 53% of the students.
2. The remaining 47% of students correctly identified an upthrust force as one that is applied to a body while it is submerged in water.

Table 5 displays the responses of students to item 4.

Table 5: Students' pattern of responses to item 4

Options	Frequency (N)	Percentage (%)
A	22	27.5
B	9	11.3
C	38	47.5
D	11	13.7
No response	0.0	0.0

Item 5

This item required students to determine whether or not an object at rest experiences forces. They were to express their opinion that for an object to remain stationary (at rest), the sum of all forces (the net force) acting on it must be zero. When a balancing force acts on an object, it will remain in place. As a result, students were required to respond yes to this item, and the forces acting on the hanging pen are the tension force exerted by the string on the pen and gravity force (the weight of the pen acting downward). It was revealed from that, only 2 (2.50%) students demonstrated sound understanding by stating that two forces act on an object (a pen) at rest, and these two forces are tension and gravity. Then, 12 (15.0%) students demonstrated a partial understanding that forces act on objects at rest, but the only force mentioned is gravity.

However, 60 (75.0%) of the students completely misunderstood the item that no force acts on an object at rest, and they were unable to name the different types of forces. The remaining six (7.5%) students do not respond to the item. It appears from the results that:

1. Most students in the class 98% of the students expressed the misconception that there is no force acting on an object at rest. Only moving objects are subject to forces, and only gravity affects objects in a resting state.
2. Only a very small percentage of students (2.0%) correctly identified normal force and gravity force as the forces that act on objects at rest. Table 6 depicts the pattern of student responses.

Table 6: Students' pattern of responses to item 5

Options	Frequency (N)	Percentage (%)
Sound understanding	2	2.5
Partial understanding	12	15.0
Total misconception	60	75.0
No response	6	7.5

Item 6

For this item, students needed to have a working knowledge of floating and how the law of floatation is applied. A floating body displaces its own weight in the fluid in which it floats, according to the law of floatation. The floating object in this scenario is the hydrometer, and it will displace its own weight through the fluid. As a result, choice A is the appropriate response to this question. It was revealed that 24 (30.0%) of the students who responded to the question provided the right answer, which stated that a hydrometer's ability to float in a liquid signifies that the weight of the liquid it has displaced is equal to the hydrometer's weight. The inaccurate explanation given by 21 (26.3%) students was that the fact that a hydrometer floats in a liquid proves that its density is greater than that of the liquid. The inaccurate notion that the hydrometer will float since its upthrust is less than its volume is also expressed by 12 (15.0%) students. Furthermore, 23 (28.7%) of the students gave the inaccurate explanation that the hydrometer will float because its volume in the liquid exceeds the quantity it displaces. The results show that:

1. Most students (70%) expressed the misconception that a hydrometer floating in a liquid meant that: the hydrometer's density was greater than the liquid's density; the internal volume of the hydrometer was less than the hydrometer's upward push; the liquid displaced is more than the volume of the hydrometer's submerged portion.
2. However, just 30.0% of students correctly replied that the weight of the liquid displaced is equal to the weight of the hydrometer submerged. As a result, the hydrometer will float in the liquid. The student response pattern to item 6 is displayed in Table 7.

Table 7: Students' pattern of responses to item 6

Options	Frequency (N)	Percentage (%)
A	24	30.0
B	21	26.3
C	12	15.0
D	23	28.7
No response	0	0.0

Item 7

This item's purpose was to assess students' knowledge of how density and flotation are applied. According to the flotation principle, a body that floats in a fluid displaces its own weight. A submarine is a type of ship that can both rise to the surface of the sea and sink beneath it. On either side, it has two tanks that are referred to as ballast tanks. These two tanks are filled with water when the submarine is ready to plunge into the ocean's depths, which makes the submarine denser than the water and causes it to sink. When it is submerged and wants to surface, these two tanks are emptied to make it less dense than the water, which allows it to float because it can displace a volume of water that is equivalent to its volume. Option C is the proper response as a result. The incorrect belief that a submarine will resurface when its pressure is reduced was expressed by 11 (13.7%) students. Out of the 80 students, 41 (51.3%) correctly said that a submarine won't surface unless the water in its two tanks is emptied out. Additionally, 28 (35.0%) students incorrectly believed that air makes the submarine float or sink. Therefore, the air inside the submarine needs to be pushed out in order for it to resurface. No student is unable to decide. It appears from the results that:

1. Some students (48.7%) expressed the misconception that a submarine's speed must be slowed down and air must be pumped out of it in order for it to resurface.
2. However, more than half of the students (51.3%) correctly understood that in order for a submarine to resurface, water must be pushed out of it so that it is less dense than the water. Students responses are shown in Table 8.

Table 8: Students' pattern of responses to item 7

Options	Frequency (N)	Percentage (%)
A	11	13.7
B	0	0.0
C	41	51.3
D	28	35.0
No response	0	0.0

Items 8

In this item, students were to explain why objects float or sink in various liquids, such as freshwater and seawater, using the principles of buoyancy. There are three requirements that must be met for an object to float or sink. If an object's density is greater than the density of the liquid it is placed in, it will sink, and vice versa. In case two, an object will sink if its entire weight exceeds the upthrust force of the liquid acting on it, and vice versa. Similar to condition three, an object submerged in a liquid must have a larger volume in order to displace a significant amount of water, or it would sink. Ships sink more readily in fresh water than in salt water because fresh water has a lower density. If a ship is loaded so that its density exceeds that of the freshwater, it will sink. Option C is the proper response to this question. The inaccurate statement that ships sink in freshwater quickly because there is no movement in freshwater was made by 22 (27.5%) students. The incorrect belief that there are more organisms in seawater and that these organisms keep the ship from sinking in the ocean than in freshwater was expressed by 16 (20.0%) students. However, out of all the students, 42

(52.5%) correctly comprehended that ships can float in seawater because it is denser than freshwater. The students each made a choice. It appears from the results that:

1. There was a widespread misunderstanding among students (47.5%) that ships sink more quickly in saltwater than freshwater because: a. seawater has more creatures; b. seawater lacks currents.
2. However, only a small majority of students (52.5%) stated the valid belief that because seawater is denser than freshwater, ships sink more quickly in freshwater than in seawater. Students' responses are shown in Table 9.

Table 9: Students' pattern of responses to item 8

Options	Frequency (N)	Percentage (%)
A	22	27.5
B	16	20.0
C	42	52.5
D	0	0.0
No response	0	0.0

Item 9

Students had to use Archimedes' principle, which states that when a body is fully or partially submerged in a fluid, it experiences an upthrust that is equal to the weight of the fluid displaced, to apply their knowledge in order to respond to this item. The object will float if the weight of the fluid displaced is equal to or greater than the weight of the object submerged in the fluid. However, if the object's weight is greater than the amount of fluid displaced, it will float in the liquid. Option B is the appropriate response to this question. Students who incorrectly stated that objects float because they displace less fluid than they weigh were 22 (27.5%). A body will float in a fluid if the weight of the fluid displacement is greater than the weight of the body submerged in the fluid, as correctly understood by 34 (42.5%) students. Only one student (1.3%) also stated an incorrect understanding of the concept that an object will rotate in a fluid if the weight of the fluid displaced is less than the weight of the object. Additionally, 23 (28.7%) students incorrectly believed that when the weight of the fluid displaced is less than the weight of the body, half of the body will be submerged in the fluid. No student omits a response to this question. It appears from the results that:

1. The majority of students (57.5%) stated the misunderstanding that an object will float or have half of it submerged in a fluid when the weight of the fluid displaced is less than that of the object.
2. However, a significant portion of students (42.5%) correctly believed that an object will float if the weight of the fluid displaced is greater than the weight of the object immersed. The students' replies to this question are shown in Table 10.

Table 10: Students' pattern of responses to item 9

Options	Frequency (N)	Percentage (%)
A	22	27.5
B	34	42.5
C	1	1.3
D	23	28.7
No response	0	0.0

Item 10

This item asked students to express their ideas on forces acting on a body at rest. It sought students to express their idea that forces act on objects at rest, provided that these acting forces are balanced and the net force is zero. At times, forces can cause a moving object to stop, but they can also cause an object to stay in place. For an object to stay at rest, the forces acting on it must be balanced. The object will only move unless an unbalanced force act on it. Sixteen (20.0%) students gave thoughtful and accurate answers to the question about how forces act on objects at rest, but only to the extent that these forces are balanced and the net force acting on the object is zero. A book placed on a table would be subject to two sorts of forces: gravity acting downward and a normal upward reaction force. Twenty (25.0%) students demonstrated a limited comprehension of how forces affect objects in motion but were unable to identify the proper forces, such as gravity and the normal reaction force. Because of the first lesson, no student stated that they completely misunderstood this item. Ineffective responses to this item total 4 (5.0%) students. The results revealed that:

1. Most of the students (80.0%) expressed some form of misconception that tension, friction, and gravity are the forces that act on an item (a ball on top of a table) at rest.
2. Only a small percentage of students (20.0%) correctly identified gravity and the normal reaction force as the only two forces that will affect the ball on top of the table. Table 11 represents students' responses to this item.

Table 11: Students' pattern of responses to item 10

Options	Frequency (N)	Percentage (%)
Sound understanding	16	20.0
Partial understanding	20	25.0
Total misconception	40	50.0
No response	4	5.0

Item 11

In this item, students were asked to distinguish between momentum and inertia. The inability of a body to move while it is at rest or to stop when it is moving in a straight line at a constant speed is known as inertia. The kilogramme (kg) is the unit of inertia. This implies that the only factor affecting an object's inertia is its mass. Inertia increases with increasing mass, and vice versa. However, a body's mass and velocity are the products of its momentum. Mathematically, momentum = mass × velocity. The unit of momentum is kilogrammes per second. A body's magnitude of momentum increases with both mass and velocity. Option C is the response that is correct for this question. After students' responses to this item, 13 (16.3%) students had the wrong idea that momentum and inertia are equivalent. Eleven (13.7%) students were unaware that the kilogramme metre per second is not the same as the inertia unit. A very high level of understanding of the idea that momentum is the sum of mass and velocity was shown by 34 students (42.5%). In addition, 19 (23.7%) students provided inaccurate responses, arguing that because inertia and momentum are identical, the unit for momentum is the same as for inertia. Three (3.8%) students chose not to respond, indicating that they were unsure of the solution. The results revealed that:

1. A prevalent misconception among students was that inertia and momentum are the same, so they have the same unit. This was voiced by the majority of students (57.5%).
2. Only 42.5% of the students correctly stated that momentum is the sum of mass and velocity. The students' replies to this question are shown in Table 12.

Table 12: Students' pattern of responses to item 11

Options	Frequency (N)	Percentage (%)
A	13	16.3
B	11	13.7
C	34	42.5
D	19	23.7
No response	3	3.8

Item 12

In order to answer this item, students must comprehend why heavier things are challenging to push or pull. A larger mass makes an object heavier and more challenging to push. An object's inertia (the resistance of a body to motion when at rest and resistance to stopping when moving with uniform velocity) is directly proportional to its mass. Because the stationary car has a higher mass than the youngster, it has more inertia. Option C is the right response to this question. The results disclosed that 17 (21.3 %) students demonstrated a false knowledge of how momentum causes a stopped car to move reluctantly when pushed. Thirteen (16.3%) students also responded wrongly to the item that moment of the car causes the car to move reluctantly. Only 35 (43.7%) students correctly answered the question, stating that the car moves reluctantly due to inertia. Additionally, 14 (17.5%) students express the incorrect belief that the car drives reluctantly when the boy pushes it because the car has an impulse. One student (1.3%) fails to respond with a suggestion. It appears from the results that:

1. The majority of students (56.3%) expressed the misconception that a car would be reluctant to start moving when pushed since it already had momentum, moment, or impulse.
2. 43.7% of the students correctly perceived that a car possesses inertia, which makes it feel reluctant to move when pushed. The responses of the students are displayed in Table 13.

Table 13: Students' pattern of responses to item 12

Options	Frequency (N)	Percentage (%)
A	17	21.3
B	13	16.3
C	35	43.7
D	14	17.5
No response	1	1.3

Item 13

Students were required to put their knowledge of the terminology used to explain motion to use. Distance, displacement, speed, velocity, acceleration, and other terms are some of the terminologies used to define motion. There are some variances between some concepts, such as distance and displacement and speed and velocity, which are sometimes used synonymously. Distance is the interval between two points, whereas a body's displacement is the distance travelled in a certain direction or its change in position with respect to its origin. Speed is the rate of change in distance. Mathematically, speed = distance travelled / time, while velocity is the rate of change in displacement or distance in a specific direction. Mathematically, velocity = displacement / time. Acceleration, on the other hand, is the rate of change in velocity. Mathematically, acceleration is equal to velocity / time. Therefore, the right answer is option B. Students who selected option A were 7 (8.7%). These students incorrectly said that acceleration is the rate at which a distance is travelled in a certain direction. Thirty-six (45.0%) of the students correctly answered the question, "Distance in a particular direction is known as displacement." Also, 14 (17.5%) people incorrectly believed that the distance travelled in a particular direction constitutes speed. Moreover, 22 (27.5%) misunderstood velocity to mean the distance travelled in a particular direction. Only one (1.3%) student failed to respond to this question. The results revealed that:

1. The majority of students (55.0%) expressed the misconception that "acceleration, velocity, or speed is defined as a distance travelled in a specific direction.
2. Few students (45.0%) correctly understood that displacement occurs when a distance is traversed in a particular direction. Table 14 shows students' responses to item 13

Table 14: Students' pattern of responses to item 13

Options	Frequency (N)	Percentage (%)
A	7	8.7
B	36	45.0
C	14	17.5
D	22	27.5
No response	1	1.3

Item 14

In this item, students were required to apply what they learned about inertia and momentum to actual circumstances. The quick brake and sharp turn of the car that occur when it suddenly stops moving exert enough force to overcome the passengers' inertia. The passenger is thrown forward as a result of the change in momentum (mass and velocity). Extreme situations could result in the passengers being thrown out of the car through the windscreen or hitting their heads or bodies against things in front of them. Students who provided sound and precise responses that when a moving car suddenly stops, the sudden brake exerts a force that overcomes the occupants' inertia and throws them forward, and the passengers could be thrown out of the car through the windscreen or strike their heads or bodies against anything in front of them were 26 (32.5%). Nineteen (23.7%) students partially understood the concept that wearing a seatbelt prevents a passenger from moving forward and perhaps injuring themselves when a car suddenly stops. Twenty- nine (36.3%) students demonstrated a complete misunderstanding of the significance of seatbelt usage for preventing accidents. Six (7.5%) students do not respond to the item. It appears from the results that:

1. A large percentage of students (77.5%) demonstrated misconception by failing to explain the true scientific concept that when a person is in a moving car without a seatbelt and the car suddenly stops, the sudden brake and the turning effect of the vehicle poses a force, which overcomes the inertia of the passengers.
2. The only danger they mentioned was that if no seatbelts were worn, the occupants might be thrown forward if the car suddenly stopped.
3. Others claimed that failing to wear a seatbelt in a moving vehicle increases the risk of an accident.

4. However, only a small portion of students (32.5%) had a firm understanding of the necessity of wearing a seatbelt while operating a moving vehicle, citing the fact that "when a person fails to wear a seatbelt in a moving car, they will be thrown out of the car when the car stops suddenly, and this is because the sudden brake of the vehicle poses a force, which overcomes the inertia of the body." Students' responses are shown in Table 15.

Table 15: Students' pattern of responses to item 14

Options	Frequency (N)	Percentage (%)
Sound understanding	26	32.5
Partial understanding	19	23.7
Total misconception	29	36.3
No response	6	7.5

Item 15

This test item was intended to assess how well the students understood the idea of a body's centre of gravity. The centre of gravity (CG) of a body is the location where the weight or mass of the body seems to be concentrated. It is the location where the entire body's mass acts. Option C is the right response to this question. Thirty-seven (46.3%) students who answered that a body's centre of gravity is where its original weight acts on the body were incorrect. Twenty-seven (33.7%) students incorrectly believed that the centre of gravity is where a body can be stable. Out of a total of 80 students, only 7 (8.75%) correctly identified the centre of gravity as the location where the body's total mass acts or is concentrated. The incorrect idea that the body's centre of gravity is the place where it is divided into two was expressed by 6 (7.5%) students. Three (3.7%) students do not respond to the question.

1. The majority of students (91.3%) expressed the misconception that a body's centre of gravity is the place where: a) its original weight acts; b) it can be stable; and c) it can be divided into two.
2. However, only a small percentage of students (8.7%) correctly understood that a body's centre of gravity is where all of its mass or weight are concentrated or act. Student responses to this question are shown in Table 16.

Table 16: Students' pattern of responses to item 15

Options	Frequency (N)	Percentage (%)
A	37	46.3
B	27	33.7
C	7	8.7
D	6	7.5
No response	3	3.7

Item 16

The concept of the centre of gravity must be understood by students in order to apply it to practical situations. Acrobats who walk on a rope with their hands extended sideways perform their entire show at one specific location on the rope in order to maintain balance. They are kept from falling as a result. By keeping their centre of gravity above and perpendicular to the rope, they are able to maintain balance. As a result, choice A is the right response. The knowledge that acrobats typically stretch their hands out to the side when they walk on a rope in order to keep their centre of gravity perpendicular to the rope was clearly understood by the 31 (38.7%) students. By doing this, they will avoid falling. The incorrect belief that acrobats do this to enhance their body surface area was expressed by 16 (20.0%) students. Eleven students (13.8%) gave the incorrect answer that it causes them to keep a narrow base on the rope. Additionally, 19 (23.7%) students expressed the incorrect belief that acrobats who balance on a rope with their hands outstretched reduce their weight. Three (3.8%) students don't correctly respond to the question. The results revealed that:

1. The majority of the students (61.3%) stated a misconception that when acrobats walked on ropes, they spread their hands out to the side in order to:
    a. Increase the surface area of their bodies
    b. Keep the rope at a narrow base
    c. Make them lighter.
2. However, 38.7% of students correctly believed that when acrobats walk on a rope with their hands extended sideways, it keeps them balanced and prevents them from falling. As a result, it keeps their centre of gravity perpendicular to the rope. Table 17 displays students' responses to this item.

Table 17: Students' pattern of responses to item 16

Options	Frequency (N)	Percentage (%)
A	31	38.7
B	16	20.0
C	11	13.8
D	19	23.7
No response	3	3.8

Item 17

Students must have a working knowledge of object stability to complete this task. A body's capacity to return to its initial static equilibrium after being slightly shifted is referred to as stability. The centre of gravity of an object must fall inside the object's base for it to return to its initial static equilibrium after being moved. The object will fall off and not return to its initial location if its centre of gravity is outside the base of that object. This equilibrium condition is referred to as an unstable equilibrium. Option D is the appropriate response to the question. Twenty-nine (36.3%) of the students incorrectly state that a wooden block will only fall from an inclined surface when its centre of gravity is low. Nineteen (23.7%) students gave the incorrect answer that the block will topple over if its centre of gravity is high. According to 12 (15.0%) students, the block will fall off the inclined plane when its centre of gravity is located within its base. Only 18 students (22.5%) correctly predicted that the block would topple over when its centre of gravity moved away from its base. Two (2.5%) of the students who attempted this task failed to respond. It appears from the results that:

1. When a wooden block is placed on an inclined plane and lifted gradually, most students (77.5%) believe that the block's centre of gravity will either be "low, high, or lies within the base when the block falls off from the plane.
2. However, only a small percentage of students (22.5%) correctly believed that when a block falls off, it will most likely land outside of its base. This happens as a result of the block becoming unstable on the plane.

Students' responses are shown in Table 18.

Table 18: Students' pattern of responses to item 17

Options	Frequency (N)	Percentage (%)
A	29	36.3
B	19	23.7
C	12	15.0
D	18	22.5
No response	2	2.5

Item 18

Students were expected to use their knowledge of the three types of equilibriums (stable, unstable, and neutral) as well as the conditions that must exist for stability to occur in this item. The lowest possible position of the centre of gravity and a broad base are prerequisites for stability. So, if a vertical line drawn from an object's centre of gravity falls inside the object's base, the object is stable. In order for the object's centre of gravity to fit inside the base, it must have a low height. Option D is the appropriate response to this question. Out of the 80 respondents, 17 (21.3%) students incorrectly believed that a body must be heavier in order to increase stability. Eleven (13.7%) students misunderstood the concept that increasing body height and base length would boost stability. Additionally, incorrect knowledge that the base length of the body must be shortened in order to increase stability was expressed by 21 (26.3%) students. Only 29 (36.3%) students correctly state that a body's base length must be increased and its height must be decreased in order to increase stability. Two (2.5%) pupils fail to select a choice, which further indicates that they do not understand the subject. It appears from the results that:

1. The majority of students (63.7%) voiced the misunderstanding that for a body's stability to increase, the body must be heavier, the body's height and base length must both rise, and there must be a reduction in base length.
2. However, only a small percentage of students (36.3%) correctly believed that in order to increase stability, the height of that particular object should be decreased and its base length increased.

Students' answers to this question are displayed in Table 19.

Table 19: Students' pattern of responses to item 18

Options	Frequency (N)	Percentage (%)
A	17	21.3
B	11	13.7
C	21	26.3
D	29	36.3
No response	2	2.5

Item 19

In this item, students had to use their knowledge of stability and the Centre of gravity. A vehicle's Centre of gravity will be lifted, not at the base, when it is heavily laden at the top. The vehicle has now reached an unstable equilibrium or will do so soon. A couple will cause the car to tip over onto its side if it is tilted. And as a result, it may quickly fall. Only 14 (17.5%) out of the 80 students, clearly understood that it is risky to load the top carrier of a vehicle heavily because doing so raises the height of the vehicle and pushes the centre of gravity away from the base. As a result, tilting the vehicle will cause it to flip over onto its side, which increases the likelihood that it could topple over. Without explaining the scientific theory underlying these effects, 17 (21.3%) students demonstrated a partial knowledge that it will lead the car to topple. Without explaining how or why, 36 (45.0%) students said they completely believed it could cause an accident. Thirteen students, or 16.2%, chose not to respond to the question. The results revealed that:

1. The majority of students (82.5%) expressed the inaccurate understanding that if a vehicle's top carrier is heavily laden, either: a. it causes an accident; or b. it topples over.

2. However, only a small percentage of students (17.5%) correctly figured out that the vehicle's centre of gravity would shift outside of its base as its height increased. As a result, tilting the vehicle will cause it to flip over onto its side, which increases the likelihood that it could topple over.

Table 20 displays the students' responses to item 19.

Table 20: Students' pattern of responses to item 19

Options	Frequency (N)	Percentage (%)
Sound understanding	14	17.5
Partial understanding	17	21.3
Total misconception	36	45.0
No response	13	16.2

Item 20

Understanding devices that use pressure in their operation was necessary for this question. Some examples of these instruments are syphons, pumps, hydraulic presses, manometers, and barometers, among others. The tool used to gauge a substance's relative or absolute density is a hydrometer. Option D is the right response to this question. Students who opted for option A were 11 (13.7%), and they incorrectly claimed that hydraulic presses do not use pressure application in their operation. Incorrectly, 13 (16.3%) students said that a syphon is a device that doesn't work by applying pressure. Additionally, 11 (13.7%) students had the incorrect impression that a bicycle pump is one of the pieces of equipment that does not use pressure. Forty-five (56.3%) students correctly identified the item in the list of options that the hydrometer is the one whose function does not involve the application of pressure. No student fails to respond with a response to this item. It appears from the results that:

1. The majority of the students (56.3%) expressed the correct conception that hydrometers do not employ pressure in their application.
2. However, a few students (43.7%) expressed misconceptions about the following devices: hydraulic presses, syphons, and bicycle pumps, which do not employ the application of pressure in their functions.

The students' answers are displayed in Table 21.

Table 21: Students' pattern of responses to item 20

Options	Frequency (N)	Percentage (%)
A	11	13.7
B	13	16.3
C	11	13.7
D	45	56.3
No response	0	0.0

Item 21

Students must remember the pressure formula for this question. Pressure is directly related to the applied force and inversely related to the object's area of contact. Option B is the appropriate response. Majority of the students, 74 (92.5%), correctly understand that the pressure of a solid object can be calculated from the expression: pressure = force / area. Only 6 (7.5%) students expressed the wrong idea that the pressure of a solid object can be calculated from the expression: pressure = force × area. No student failed to respond to this item. The results depict that:

1. Very few students (7.5%) expressed the misconception that the pressure of an object is calculated from the formula: pressure = force × area.

2. The majority of the students (92.0%) expressed the correct conception that the pressure of an object is calculated from force on area.

Students' response patterns are shown in Table 22.

Table 22: Students' pattern of responses to item 21

Options	Frequency (N)	Percentage (%)
A	0	0.0
B	74	92.5
C	0	0.0
D	6	7.5
No response	0	0.0

Item 22

This question focused on factors that can affect pressure either directly or indirectly. As explained above, if the surface area increases, pressure will decrease. But as force decreases, pressure decreases, and vice versa. Therefore, the correct response is option A. Students who correctly identified the statement that pressure does not increase as the surface area increases were 33 (41.2%). 12 (15.0%) students are unable to appropriately communicate their belief that pressure reduces as surface area increases. They were unable to convey the relationship between pressure and area, which implies that when pressure decreases, surface area increases and vice versa. Sixteen students (20.0%) incorrectly believed that a body's pressure wouldn't increase as its surface area shrinks. Thirteen students (16.3%) demonstrated the incorrect notion that the pressure exerted will not increase but rather decrease as the force applied to a body increases. Six (7.5%) students do not respond to the item. The results revealed that:

1. The majority of the students (58.8%) expressed the misconception that the pressure of a body depends on the surface of the body, and not the force exerted or the area

in contact. Therefore, if the surface area increases, pressure will not decrease, and vice versa. Also, if force increases, pressure will not increase, and vice versa.

2. However, few students (41.2%) expressed the correct conception that the pressure of a body does not depend on a surface but rather depends directly on the force acting on the object and inversely on the area in contact.

Table 23 shows students' responses.

Table 23: Students' pattern of responses to item 22

Options	Frequency (N)	Percentage (%)
A	33	41.2
B	12	15.0
C	16	20.0
D	13	16.3
No response	6	7.5

Item 23

In this item, students' ideas on atmospheric pressure or pressure in gases are required. Gases move as a result of pressure differences. Gases move from higher-pressure (low temperature) areas to lower-pressure (high temperature) areas. The bigger the difference between pressures, the faster the air moves from low to high pressure. The rush of air is the wind we experience. Therefore, the right answer is option C. Seventeen (21.3%) students incorrectly believed that a wind is caused by the force acting on it. When there is a difference in height, 6 (7.5%) students said it causes wind. Only 32 (40.0%) students correctly stated that a pressure differential is what causes wind. According to 21 (26.2%) students, the causes of wind are independent of the force operating on it, the difference in height, and the difference in pressure. Four (5.0%) students struggle to express their thoughts. It appears from the results that:

1. Most of the students (60.0%) expressed the misconception that wind is caused by force and a difference in height, or that it cannot be caused by any of these factors.
2. Few students (40.0%) expressed the correct conception that a wind is caused by a pressure difference.

Table 24 shows the students response patterns.

Table 24: Students' pattern of responses to item 23

Options	Frequency (N)	Percentage (%)
A	17	21.3
B	6	7.5
C	32	40.0
D	21	26.2
No response	4	5.0

Item 5

The item focused on pressure in liquids. In this item, students were expected to apply their understanding of factors that affect pressure in liquids. Factors that affect pressure in liquids are the density of the liquid, the height (depth) of the vessel containing the liquid, and the acceleration of gravity acting on the liquid. The speed at which the liquid comes out of the vessel depends on its height. The higher the height, the greater the speed at which the liquid comes out. Therefore, the correct option is D. It was observed that 17 (21.3%) students expressed the wrong understanding that if a small hole is made at the bottom of a vessel containing water, the speed at which the water will come out of the hole depends on the density of the vessel. Seventeen (21.3%) students expressed their understanding of this same question: that the speed of the water will depend on the volume of the vessel. Seven (8.7%) responded that the speed of the water depends on the mass of the vessel. Only 36 (45.0%) students responded correctly that the speed at which the water will come out of the vessel depends on the height of the vessel since pressure increases with height. It appears from the results that:

1. The majority of the students (55.5%) expressed the misconception that pressure does not increase with height, therefore, the density, volume, and mass of the vessel will influence the flow of the water.
2. Few students (45%) expressed the correct conception that pressure increases with height. Therefore, if the hole made in the vessel containing the liquid is at a certain height, the liquid will come out easily.

Table 25 shows the response pattern of students to this item.

Table 25: Students' pattern of responses to item 5

Options	Frequency (N)	Percentage (%)
A	17	21.3
B	17	21.3
C	7	8.7
D	36	45.0
No response	3	3.7

Item 25

This item required students to apply their understanding of the application of pressure in our daily lives. Cutting and piercing tools are made sharp so as to have a greater pressure at the edge of the tool, even for a small applied force, to make their cutting or piercing action sharp and quick. Students who correctly responded that when cutting and piercing tools are made sharp, it decreases the surface area of the tool, which increases the pressure when a force is applied were 30 (37.5%). As a result, making cutting and piercing easier. Sixteen (20.0%) showed partial understanding that cutting and piercing tools are made sharp because it makes cutting and piercing easy. Thirty-four (42.5%) students showed total misconception of the item that "cutting and piercing tools are made sharp in order to penetrate or cut through something so as to reduce friction. Cutting and piercing tools are made sharp so that when used, the pressure applied is very little, but the tools still work effectively." No student fails to respond to the item. The results revealed that:

1. The majority of the students (62.5%) expressed the misconception that when a cutting tool is sharpened, it makes cutting easy and reduces friction. Also, they are made sharp to reduce the pressure exerted on them, which makes the tool work effectively.
2. However, only a few students (37.5%) expressed the correct conception that cutting and piercing tools are made sharp so as to have a greater pressure at the edge of the tool since its surface area will reduce, and even for a small applied force, its cutting or piercing action will be sharp and quick.

Table 26 shows students' responses to this question.

Table 26: Students' pattern of responses to item 25

Options	Frequency (N)	Percentage (%)
Sound understanding	30	37.5
Partial understanding	16	20.0
Total misconception	34	42.5
No response	0	0.0

Table 27 summarises all of the outcomes of the SMDT on force, motion, and pressure during the four weeks of experimental teaching in accordance with the CCM concepts (CCM force concepts one and two, CCM motion concepts one and two, and CCM pressure concept). The first ten items are the CCM force concept, the CCM motion concept (items 11 to 19), and the CCM pressure concept (items 20 to 25). Partial understanding and all unsolved questions were also considered to be kinds of misconceptions.

Table 27: Results of all the five SMDT on force, motion and pressure

Items	Students with right conception	Percentage (%)	Students with misconception	Percentage (%)
1	41	51.3	39	48.7
2	35	43.7	45	56.3
3	31	38.8	49	61.2
4	38	47.5	42	52.5
5	2	2.5	78	87.5
6	42	30.0	56	70.0
7	41	51.3	39	48.7
8	42	52.5	38	47.5
9	34	42.5	46	57.5
10	16	20.0	64	80.0
11	34	42.5	46	57.5
12	35	43.8	45	56.2
13	36	45.0	44	55.0
14	26	32.5	54	67.5
15	7	8.7	73	91.3
16	31	38.7	49	61.3
17	18	22.5	62	77.5
18	29	36.3	51	63.7
19	14	17.5	66	82.5
20	45	56.3	35	43.7
21	74	92.5	6	7.5
22	33	41.3	47	58.7
23	32	41.3	47	58.7
24	36	45.0	44	55.0
25	30	37.5	50	62.5

Research question one

What are some of the misconceptions that SHS students have about some topics in Integrated Science? Table 28 shows some misconceptions of students about some integrated science topics (force, motion and pressure)

Table 28: Some misconceptions of students on force, motion and pressure

Topics	Common Misconceptions of students in the science classroom
Force	**Misconceptions**
1	The mass of a body can be change if force is applied
2	Objects feel weightless in space because the acceleration due to gravity of the earth balances that of the sun and there is absence of air and force of gravity in space.
3	Frictional force between two bodies in contact depend on 'the area, speed and moment of the bodies in contact
4	No force act on object at rest. Forces only act on object in motion. Gravity is the only force that act on object at rest.
5	Hydrometer float in liquid because density of the hydrometer is greater than the density of the liquid, upthrust on the hydrometer is less than the volume of the hydrometer and volume of the portion of the hydrometer in the liquid is greater than the volume of the liquid displaced.
6	When the weight of a fluid displace is less than that of the weight of the object, the object will float or half of it will be immersed in the fluid
Motion	**Misconceptions**
1	Inertia and momentum are the same therefore they have the same unit
2	A stationary car feels reluctant to move when been push because the car has momentum, moment or impulse
3	Acceleration, velocity or speed are terms which are defined as a distance travelled in a specific direction.
4	Failure to wear seatbelt in a moving vehicle leads the vehicle to accident
5	Centre of gravity of a body is the point where its original weight acts
6	Acrobats stretched their hands sideways when walking on ropes to increase the surface area of their body, maintain a narrow base on the rope and decrease their weight.
7	For a body's stability to increase the body must be heavier, and the height and base length of the body must increase
8	When the top carrier of a vehicle is loaded heavy it will lead the vehicle to accident
Pressure	**Misconceptions**
1	Pressure of a body depends on the surface of the body
2	Wind is caused due to force and difference in a height
3	A cutting tool is made sharp to make cutting easy to reduce friction. And also, to make the pressure exerting on it little
4	The speed in which water come out from a vessel depends on density, volume and mass of the vessel.

Research question two

What effect does the conceptual change model have on changing SHS students' misconceptions on some Integrated Science topics?

The second research question sought to investigate whether there is a difference in the performance of students in the above lessons taught (force, motion, and pressure) using the conceptual change model. To do this, a general test, which comprises all the SMDT on the five lessons, was given to students after implementing the conceptual change model approach. This test was known as the science performance test (SPT).

SPT results discussion on force, motion and pressure

After the implementation of the Conceptual Change Model approach, the results from the SPT revealed that almost all the students (100.0%) were able to describe force as the push or pull of an item that modifies the condition of that object using a scientific explanation and the following types of forces (tension, gravity, friction, magnetic, and viscosity) could be mentioned and explained by the students. The students could also define upthrust as the force that pushes an object back to the surface of a liquid. Seventy-five students representing 93.7% could discuss the effects of forces on objects, such as how they can alter an object's speed, shape, or direction and not it's mass. Out of the 80 respondents, 76 (95.0%) students could explain that items float because of their lower density relative to water or sink because of their higher density relative to water. Seventy-eight students (97.5%) were able to apply the flotation principle, which states that a floating body displaces its own weight through the fluid in which it floats. All students (100.0%) could differentiate between distance and displacement, speed, velocity, and acceleration, inertia and momentum. The majority of students (92.5%) could explain why it is important to wear a seatbelt that, it prevents the passenger from throwing out of the car through the windscreen when the car suddenly stop. Out of the

92.5% of students, 81.3% could explain the law that governed it as the law of inertia. The majority of students (91.3%) could explain the three types of equilibrium states and state conditions for a body to be stable. Sixty-seven students (83.7%) could explain the implication of loading the top carriers of a vehicle so heavily that, it can cause the vehicle to be unstable and topple over when tilted slightly. Also, the scientific theory underlying why cutting instruments are made sharp could be explained by majority of the student (82.5%) as follows: cutting and piercing tools are made sharp to reduce the surface area and increase the pressure exerted on them to make cutting and piercing easier. It appears from the results that majority of students' misconceptions on force, motion and pressure have been remediated and students have gained sound understanding on the topic. This confirm what Schmidt et al (2006) proposed, "the strong strategy that could identify students' naive conceptions, recognize them and replace them with accurate conception is the Conceptual Change Model." The SPT item by item scores of students on the concepts of force, motion, and pressure yielded the following results as shown in Table 29.

Table 29: Students response pattern of the SPT on force, motion and pressure

Items	Students with right conception	Percentage (%)	Students with misconception	Percentage (%)
1	71	88.7	9	11.3
2	75	93.7	5	6.3
3	79	98.7	1	1.3
4	80	100.0	0	0.0
5	69	86.3	11	13.7
6	74	92.5	6	7.5
7	80	100.0	0	0.0
8	78	97.5	2	2.5
9	78	97.5	2	2.5
10	75	93.7	5	6.3
11	76	95.0	4	5.0
12	80	100.0	0	0.0
13	78	97.5	2	2.3
14	79	98.7	1	1.3
15	80	100.0	0	0.0
16	78	97.5	2	2.5
17	76	95.0	4	5.0
18	79	98.7	1	1.3
19	73	91.3	7	8.7
20	65	81.3	15	18.7
21	62	77.5	18	22.5
22	64	80.0	16	20.0
23	74	92.5	6	7.5
24	67	83.7	13	16.3
25	66	82.5	14	17.5

To investigate possible significant difference in student performance from their SPT, an analysis was done by comparing the Students Misconception Diagnostic Test (SMDT) and the SPT using t- test. Table 30 shows a statistically significant difference between the means scores of the SMDT and the SPT.

Table 30: Results of t-test analysis for students SMDT and SPT scores

Variable	N	Mean	SD	t	df	p
SMDT	80	1.00	0.00		78	0.001
				-2.054		
SPT	80	1 .42	0.497		78	

From Table 29, students mean scores from the Science Performance Test (SPT) was significantly **higher (*M = 1.42, SD = 0.497*)** than the students mean score from the Students Misconception Diagnostic Test (SMDT), thus, (***M = 1.00, SD = 0.00, t = -2.054, p < 0.001***). It appears from the results that, the use of the conceptual change model as a teaching strategy has increased the understanding and performance of students. This shows clearly from Tables 29 and 30 that the majority of students' misconceptions on force, motion, and pressure identified in Table 28 have been remediated through the intervention. And the majority of students have now gained a correct conception of force, motion, and pressure.

Research question three

What are SHS students' perceptions of the conceptual change model as a teaching strategy for changing their misconceptions about some Integrated Science topics? To identify the perception of students about the use of the conceptual change model, an interview was conducted with 16 students, eight from each class. The same interview question was given to each student to avoid bias. The following questions were asked during the interview process:

1. Did you identify any misconception you have on the concept force, motion and pressure when taught with the conceptual change model approach?

2. i. Has the conceptual change lesson improved your understanding on the force, motion and pressure concepts?

   ii. How has the CCM addressed your identified misconceptions?
3. i. What was your expectation in terms of performance in the Science Performance Test after the intervention?

   ii. Did you receive total, partial or no remediation of misconception after the conceptual change lessons?
4. Did your instructor consider individual needs and interests when using the conceptual change model as an instruction?
5. How was your feeling when participating in the lesson; force, motion and pressure when taught through the conceptual change model?
6. If you were given the chance, would you choose to be taught through the conceptual change model instructions mostly?

At the end of the interview section, the data collected from the students was analysed using content analysis, where the researcher discussed the responses of the students. During the analysis of the interview data, two themes emerged. These are;

1. Students' misconception
2. Teacher's instruction

Students' misconception

From the interview questions, items 1, 2ii, and 3 focus on students' misconceptions. All the participants (100.0%) responded yes to item one, saying that they have one way or another identified some misconceptions they have on the topic of force, motion, and pressure. Out of the entire 16 participants, 13 (81.3%) of them have had their identified misconceptions of the topic addressed and also gained a sound understanding. For the other 3 students (18.7%), two responded that out of the five lessons taught, they received a sound understanding of the first four lessons. In the last lesson (the CCM pressure lesson), they received partial understanding. The last one said, "I was confused with some of the concepts in motion because I was taught in JHS that inertia is a force, which means its unit should be Newton. So why kilogramme? She also stated that she has gained more understanding of the first two lessons on forces and a partial understanding of the concept of pressure. From interview question 3 (i), 12 (75.0%) of the participants responded that they are expecting 30 out of 30 from the SPT, which means that their misconceptions have been totally remediated. Three (18.7%) said more than 27, and the other one (6.3%) said at least 25. All 16 (100.0%) students responded that they had received some form of remediation for their identified misconceptions, but whether it was total or partial depended on the lesson. Most of the students (87.5%) reported that they received total remediation in at least three of the lessons, while in the other two lessons they received partial remediation. None of the participants (0.0%) responded that they have received 'no remediation' for their identified misconceptions on the topic. It appears from the results that:

Students indeed have varying ideas in the science classroom that contradict accurate scientific concepts, as posited by Chan et al (2020). These inaccurate scientific ideas is what Halim et al (2018) suggested that it should be addressed in every science lesson presented to the students to enhance their understanding of the lesson.

Teacher's instruction

Item 2i, 4, 5, and 6 of the interview questions focus on the teacher's or researcher's instruction. The teacher's instruction is what is termed the Conceptual Change Model (CCM). From the interview item 2i, about 87.5% of the participants responded that the conceptual change lesson on force, motion, and pressure has really improved their understanding of the topic of force, motion, and pressure as compared to the traditional instruction used to teach them (n = 14). The other 2 (12.5%) said not all the lessons, but some. Out of the 16 participants, 10 (62.5%) responded to item 4: "Yes, individual needs were considered during the CCM force, motion, and pressure concepts. For example, one student said, "You gave us the chance to discuss what we know on the topic with our friends, and through that, we received a lot of ideas that added up to our understanding." One student also said, ‘I was happy when you involved a lot of activities throughout the lessons and also gave us the opportunity to express our ideas without intimidating us or allowing our own colleagues to intimidate us when we were wrong'. Some students (37.5%) also responded that ‘yes, individual needs were paid attention to, but not everyone. One student said, "Because I was sitting at the back, you never called me to answer questions when I raised my hand, and I felt bad." Another student also reported that ‘those in front were more engaged than those sitting at the back." Another student also reported that ‘I was finding it difficult to see some of the activities and also some writings from the board. But because you were speaking louder, I was able to understand’. In item five of the interview questions, almost all the participants (93.8%) responded that the lessons were interesting because of the activities involved. Also, because it was a kind of demonstration and discussion, it really helped them understand most of the concepts they didn’t understand before. Therefore, they really enjoyed this method of teaching. But a few students (6.2%) reported that they were feeling shy about asking questions about some of the concepts in the topic. This is because they think all their friends have understood, so it will be embarrassing to ask questions on concepts most of the students have understood. All the students (100.0%) responded yes to item six, and the majority (93.8%) even suggested that the conceptual change model instruction should be employed in other subjects to help them understand. It appears from the results that:

The conceptual change Model has been a powerful strategy in identifying and addressing most students misconceptions on some selected Integrated Science topics. This agrees with the result proposed by Yenilmez and Tekkaya (2006) that "Conceptual Change Model approach are wont to correct a large percentage of students misconceptions, helps students review their preconceptions and supports the teacher to look at the student's concepts." However, individual needs should be an important thing a teacher should consider when using any teaching method or instruction to teach. Though the majority of the students understood the topic and their misconceptions were remediated when using the conceptual change model instruction, some students needs were not looked at, which prevented them from asking questions or responding to questions in the CCM lessons, through which these students could not gain total remediation for their identified misconception.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

5.0. Overview

This chapter gives the summary of the findings, recommendations and salient issues that emerged from the study. The chapter also draws conclusion on the outcome of the study and provides suggestions for further research.

5.1 Summary of Findings

This study was conducted to remediate students' misconceptions in some selected integrated science topics. The topic selected was force, motion and pressure. The findings of this study were grouped into three part as follows:

1. Students misconception about force, motion and pressure
2. Students correct conceptions about force, motion and pressure after the conceptual change model
3. Students perceptions about the use of the conceptual change model as an intervention

Students Misconceptions about force, motion, and pressure

An analysis of students' responses from the Students Misconception Diagnostic Test (SMDT) on the CCM force, motion, and pressure concepts reveals the following as misconceptions students have about force, motion, and pressure:

Misconceptions about force

1. The mass of a body can be change if force is applied
2. Objects feel weightless in space because the acceleration due to gravity of the earth balances that of the sun and there is absence of air and force of gravity in space.
3. Frictional force between two bodies in contact depend on ‘the area, speed and moment of the bodies in contact
4. No force act on object at rest, forces only act on object in motion.
5. Gravity is the only force that act on object at rest.
6. Hydrometer float in liquid because density of the hydrometer is greater than the density of the liquid, upthrust on the hydrometer is less than the volume of the hydrometer and volume of the portion of the hydrometer in the liquid is greater than the volume of the liquid displaced.
7. When the weight of a fluid displace is less than that of the weight of the object, the object will float or half of it will be immersed in the fluid

Misconceptions about motion

1. Inertia and momentum are the same therefore they have the same unit
2. A stationary car feels reluctant to move when been push because the car has momentum, moment or impulse
3. Acceleration, velocity or speed are terms which are defined as a distance travelled in a specific direction.
4. Failure to wear seatbelt in a moving vehicle leads the vehicle to accident
5. Centre of gravity of a body is the point where its original weight acts

6. Acrobats stretched their hands sideways when walking on ropes to increase the surface area of their body, maintain a narrow base on the rope and decrease their weight.
7. For a body's stability to increase the body must be heavier, and the height and base length of the body must increase
8. When the top carrier of a vehicle is loaded heavy it will lead the vehicle to accident

Misconceptions about pressure

1. Pressure of a body depends on the surface of the body
2. Wind is caused due to force and difference in a height
3. A cutting tool is made sharp to make cutting easy to reduce friction. And also, to make the pressure exerting on it little
4. The speed in which water come out from a vessel depends on density, volume and mass of the vessel.

Students correct conception about force, motion and pressure after the conceptual change teaching approch

Analysis of the various lessons presented and the science performance test (SPT) administerd after the five lessons on force, motion, and pressure reveals the following findings:

Correct conception about force

1. A force can change the shape, speed, and direction of a body but not its mass.
2. Objects are weightless in space because their weigh balances the force of gravity
3. Frictional force is affected by the nature of the two surfaces in contact not the area of surfaces in contact.

4. Upthrust force is the force which act on objects placed in fluid (e.g., water)
5. Force act on object at rest but these forces are balanced
6. An object float in water because it displaces a weight of water equal to its weight
7. When the weight of fluid displaced is less than the weight of the object submerged, the object will sink

Correct conceptions on motion

1. Inertial is not the same as momentum. The unit for inertia is kilogram and that of momentum is kilogram metre per second
2. An object fells reluctant to move because of its inertia
3. The distance travelled in a specified direction is known as displacement.
4. Failing to wear a seatbelt in a moving car causes the passengers in the car to thrown out of the car when the car stops suddenly, and this is because the sudden brake of the vehicle poses a force, which overcomes the inertia of the passengers.
5. The centre of gravity of a body is the point where the total weight of the body is concentrated.
6. Acrobats walk on a rope with their hands extended sideways to keep them balanced and prevents them from falling.
7. An object will fall off from a plane when its centre of gravity falls outside its base.
8. To increase stability, the height of that particular object should be decreased and its base length increased.

Correct conception about pressure

1. The pressure of a body does not depend on a surface but rather depends directly on the force acting on the object and inversely on the area in contact.
2. Wind is caused due to pressure or temperature difference.

3. Pressure in liquids increases with depth or height
4. Cutting and piercing tools are made sharp so as to have a greater pressure at the edge of the tool since its surface area will reduce, and even for a small applied force, its cutting or piercing action will be sharp and quick.

Students perceptions about the use of the conceptual change model as an intervention

The analysis of the interview responses on the use of the CCM approach after the intervension reveals the following findings:

1. The use of CCM has remediated most of the students' misconceptions about force, motion, and pressure, as listed above.
2. Students' interest in solving questions on force, motion, and pressure has been aroused, and their attitude towards learning has been transformed.
3. Involving the students during the CCM lesson presentation makes them feel like part of the class and therefore influences their understanding of the concepts positively.
4. Students' needs and interests, which were taken into consideration during the CCM lessons, helped them perform much better in the Science Performance Test (SPT) than the Students' Misconception Diagnostic Test (SMDT).
5. Almost all the students wish to be taught through the conceptual change teaching approach due to the numerous activities, demonstrations, and discussions it involves.

5.2 Conclusions

Based on the study's findings, it was determined that Form 2 Wesley Girls' High School students have a variety of beliefs that run counter to true scientific principles, particularly when it comes to the concepts of force, motion, and pressure. The Form 2 Wesley Girls' High Integrated Science students' beliefs about force, motion, and pressure may have prevented the development of new ideas in these areas, and they can undoubtedly be passed on to the next generation. In correcting these misconceptions students have about the concepts of force, motion, and pressure, the conceptual change model (CCM) method has proven to be more successful. The student's understanding of the ideas of force, motion, and pressure has also enhanced attributable to the CCM approach.

5.3 Recommendations

In light of the study's findings regarding students' misconceptions of force, motion, and pressure, the impact of using the conceptual change model as a teaching strategy, and the educational implications it will have, the following recommendations were made:

1. Seven misconceptions about forces, eight about motion, and four about pressure emerged after the analysis of the students' misconception diagnostic test, as shown above. Before teaching students about these topics, science teachers must first identify their students' preconceptions about these concepts. By doing this, they may sort out any misconceptions that students may have and better prepare how to present their lessons.
2. In class, science teachers should use everyday activities from their students' surroundings to create scenarios that will test their understanding of the concept and correct any misconceptions they may have when teaching forces.

3. Science teachers should involve their students in activities and demonstrations that will assist them clarify the meanings of each term used to describe motion to their students.
4. To help students understand why they should apply the concept of pressure in their daily lives, science teachers should use a variety of activities that are similar to the students.
5. With regard to the application of the conceptual change model as a teaching strategy, science teachers should use a conceptual change approach to educate and correct students' misconceptions about integrated science concepts in order to promote conceptual change and raise their interest in solving scientific problems.
6. Teachers should involve their students in the teaching and learning process by making their lessons engaging and activity-based.
7. Teachers should do well to consider the needs and interests of their students while teaching and learning.
8. To expose students to proper and incorrect conceptions of the subject beforehand, the conceptual change model technique should be employed when teaching students in other scientific subjects, such as physics, biology, and chemistry.

5.4 Suggestions for further research

1. The study should be replicated using the conceptual change model approach in other regions and districts in Ghana.
2. Further research needs to be conducted to identify the limitations of the conceptual change model approach.
3. In-service training should be organised for integrated science teachers to train them effectively on the use of the conceptual change model as a teaching strategy.

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APPENDICES

Appendix A 1

Lesson Plan for Teaching Selected Topics in Integrated Science (Force, Motion, And Pressure) Using the Conceptual Change Model

LESSON 1

Date: 6/6/2022 **Class**: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: FORCE

References

Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

Schmidt, D. L., Saigo, B.W., Stepans, J. I. (2006). *Conceptual Change Model*: The CCM Handbook. Saiwood Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 35-36

Relevant Previous Knowledge: Students have an idea of the meaning of force and some types of forces.

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

1. explain the meaning of force
2. list the various types of forces
3. state the effect of force on an object

Teaching and Learning Materials:

Table, elastic string, book, and stones

Teacher- Learner Activities

Introduction: teacher introduces the topic by first of all identifying the students' misconceptions on the topic using the SMDT on the lesson.

Activity one: teacher brainstorms students to bring out the meaning of force by placing a book on top of a table and asks students to pull or push.

Activity two: teacher discusses with students the various types of forces and carry out activities to demonstrate each one of them with the students.

Activity three: Teacher discusses with students the meaning of upthrust (a type of force) by placing a cork in the water and asks students to observe and record what happens.

Activity four: teacher demonstrates and discusses with students the effect of forces on a body by:

a. Stretching a piece of elastic string
b. Pushing an object
c. Stopping a moving object.

CORE POINT

- **Distribution of SMDT on CCM force concept -lesson one**
- **Meaning of force:** force is a pull or push of an object. Or force is anything that changes the state of an object at rest or of uniform motion in a straight line.

Figure 2: Demonstration of force as pull or push

Types of force: viscous, gravitational, electrostatic, magnetic, upthrust/ buoyant, tension,

Weight.

Figure 3: Types of force

Upthrust/ buoyant force: it is the upward force exerted by a fluid vertically on a body placed in the fluid. The upthrust of fluid is equal to the apparent loss of weight of the object immersed in the fluid and it is also equal to the weight of the fluid displaced by the object.

- **Effect of force on objects:**

i. It changes the shapes or deforms the shapes of solid objects or elastic materials

ii. It causes an object to move

iii. It causes a moving object to stop

iv. It changes the direction of moving objects. Etc.

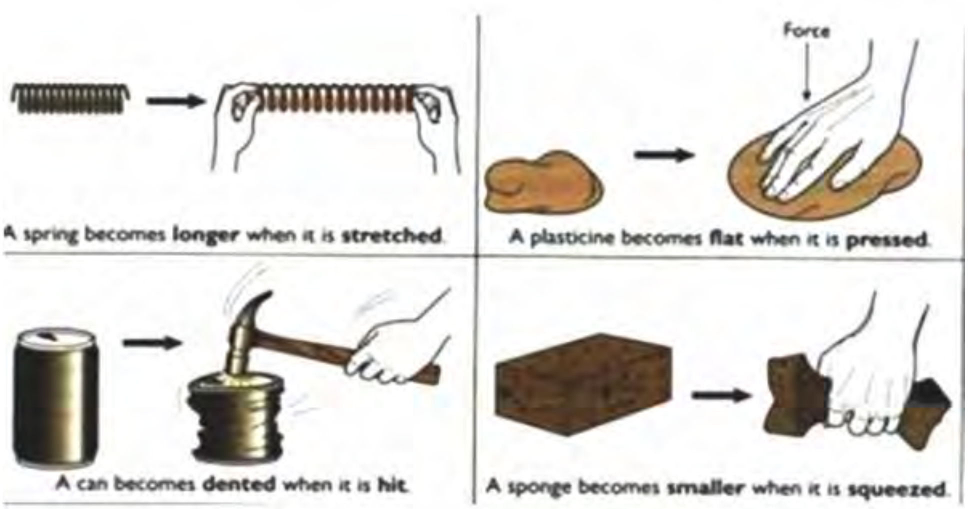

Figure 4: Effect of force on objects

Conclusion: teacher brings the lesson to an end by giving students the chance to ask questions on the concept that challenges their prior knowledge or assumptions and helps them to address it.

Evaluation

1. Identify the forces that act on a book at rest?
2. Identify the type of force that will cause the book to move when pull or push
3. Define force

APPENDIX A 2

LESSON 2

Date: 10/6/2022 **Class**: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: FORCE

References:

Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

Schmidt, D. L., Saigo, B.W., Stepans, J. I. (2006). *Conceptual Change Model*: The CCM Handbook. Saiwood Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 35-36

Relevant Previous Knowledge: students have pulled or pushed an object to explain the meaning of force. Students have ideas on the types and effects of forces.

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

1. state the Archimedes principle and law of flotation
2. explain some phenomenon using Archimedes principle and law of floatation

Teaching and Learning Materials:

Water in a bowl, wooden objects, metallic objects, a cork

Teacher- Learner Activities

Introduction: teacher reviews the relevant previous knowledge of the students. Teacher diagnoses students' preconception of the concept by administering the SMDT on the lesson.

Activity one: teacher discusses the Archimedes principle to students by asking students

Activity two: teacher explain to students the law of floatation by placing wooden and metallic objects with different masses or weights into water. Teacher asks students to observe and record what they see.

Activity three: teacher place a fresh egg in water and then in concentrated salt solution and asks the students to explain the observation in each case.

CORE POINTS

- **Distribution of SMDT on CCM Force Concept -Lesson Two**

Archimedes' principle states that when a body is wholly or partially immersed in a fluid, it experiences an upthrust which is equal to the weight of the fluid displaced.

The law of floatation states that a floating body displaces its own weight in a fluid in which it floats. Or, It states that the weight of a fluid displaced by a floating body is equal to the weight of the floating body.

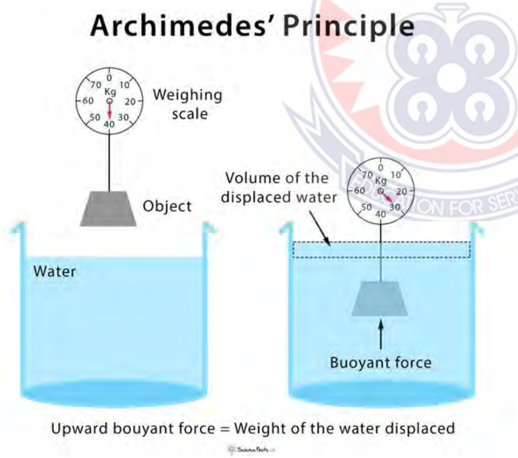

Figure 5: Demonstration of the Archimedes principle and law of floatation

Conclusion: teacher brings the lesson to an end by giving students the chance to ask questions on the concept that challenges their prior knowledge or assumptions and helps them to address it.

Evaluation

1. What causes the volume of water to increase when a wooden object is placed into it?

2. Why does a cork float in water but a coin sink in water?
3. State the principle of floatation
4. Why do boat floats in water?

APPENDIX A 3

LESSON 3

Date: 20/6/2022 **Class**: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: MOTION

References

Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

Schmidt, D. L., Saigo, B.W., Stepans, J. I. (2006). *Conceptual Change Model*: The CCM Handbook. Saiwood Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 35-36

Relevant Previous Knowledge: students have ideas on motion and types of motion.

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

3. explain the terms distance, displacement, speed, velocity, acceleration,
4. distinguish between the term inertia and momentum
5. express the relationship between these terms listed in one and two above.

Teaching and Learning Materials:

Table, marker board illustration

Learners' Activities

Introduction: the researcher reviews the relevant previous knowledge of students on motion and types of motion by asking them simple questions. The researcher administers the SMDT on the lesson to students to diagnose their misconceptions on the CCM motion concept. **Activity one:** the researcher brainstorms students to bring out the meaning of the following terms; distance, displacement, speed, velocity, acceleration.

Activity two: teacher explains the relationship between these terms to students and assists them to solve problems.

Activity three: the teacher explains to students the concept of inertia and momentum.

CORE POINTS

- **Distribution of SMDT on CCM Motion Concept**

  Terms associated with motion

- **distance** is the magnitude of displacement or the interval between two points.
- **Displacement** is the distance travelled by a body in a specific direction or the position of a body relative to its origin.
- **Speed** is the rate of change in distance. Mathematically, speed = distance travelled / time
- **Velocity** is the rate of change of displacement. Mathematically, velocity = displacement / time.
- **Acceleration:** Is the rate of change of velocity. Mathematically, acceleration = $velocity/(time\ taken)$.

Inertia: this is the reluctance of a body to move when at rest and to stop when moving with uniform velocity in a straight line. The unit of inertia is ***kilogram (kg).*** this means that an object's inertia depends solely on its mass. The greater the mass, the greater the inertia and vice versa.

Momentum: this is the product of mass and velocity of a body. Mathematically, momentum $= mass \times velocity$.

Conclusion: teacher brings the lesson to an end by giving students the chance to ask questions on the concept that challenges their prior knowledge or assumptions and helps them to address it.

Evaluation

6. distinguish between the following terms; a. distance and displacement b. speed and velocity c. inertia and momentum
7. i. Find the momentum of a body of mass 1000kg moving at a speed of $20ms^{-1}$.

   ii. if the speed of the body changes to $40ms^{-1}$ in 2s, calculate its average acceleration.
8. Why is it important to wear seat belt when you are in a moving vehicle?

APPENDIX A 4

LESSON 4

Class: 2A3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: MOTION

References

Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

Schmidt, D. L., Saigo, B.W., Stepans, J. I. (2006). *Conceptual Change Model*: The CCM Handbook. Saiwood Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 35-36

Relevant Previous Knowledge: students have ideas on Centre of gravity and stability.

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

1. define Centre of gravity
2. Explain the meaning of equilibrium
3. distinguish between stable, unstable, and neutral equilibrium

Teaching and Learning Materials:

Table, three cones

Learners' Activities

Introduction: teacher reviews the relevant previous knowledge of students on physical quantities used in motion by asking them simple questions on it. The researcher administers the SMDT on the fourth lesson to students to diagnose their misconceptions on the CCM motion concept.

Activity one: the researcher demonstrates the Centre of gravity of rectangular shaped object (meter rule) to students using the knife edge method

Activity two: teacher demonstrates the three types of equilibrium to students using a cone on a flat surface.

Activity three: teacher discusses with students the effect of loading a vehicle on the top carrier or on the base carrier on the stability of the vehicle.

CORE POINTS

- Administration of the SMDT on the CCM motion concept two
- The use of knife edge method to determine the Centre of gravity of a rectangular

The **centre of gravity** of all bodies can be **determined** by balancing the body on a **knife edge** or by suspension with a plumb line from several points. The **centre of gravity** (CG) is where all of the weight of an object appears to be concentrated.

- **Types of equilibrium using a cone on a flat surface**

  There are three types of equilibrium namely, stable, unstable, and neutral equilibrium.

  Stable equilibrium: A system is said to be in stable equilibrium if, when displaced from the equilibrium position, it experiences a net force or torque in a direction opposite to the direction of the displacement.

  Unstable equilibrium: A system is in unstable equilibrium if, when displaced, it experiences a net force or torque in the *same* direction as the displacement from equilibrium. A system in unstable equilibrium accelerates away from its equilibrium position if displaced even slightly.

  Neutral equilibrium: A system is in neutral equilibrium if its equilibrium is independent of displacements from its original position.

Effect of loading a vehicle on the top carrier or the base carrier on the stability of the vehicle.

Stability refers to the ability of a body to restore to its original static equilibrium, after it has been slightly displaced.

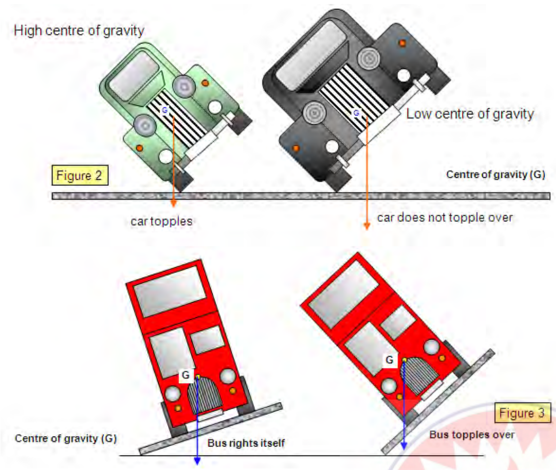

Figure 6: Effect of stability on object

Conclusion: teacher brings the lesson to an end by giving students the chance to ask questions on the concept that challenges their prior knowledge or assumptions and helps them to address it.

Evaluation

1. distinguish between the three types of equilibrium
2. Why is it dangerous to load the top carriers of vehicles heavy?

APPENDIX A 5

LESSON 5

Date: 27/6/2022 **Class**: 2S3 and 2A4

Class size: 80 **Duration**: 110 minutes

Topic: FORCE, MOTION, AND PRESSURE **Subtopic**: PRESSURE

References

Obeng, A. K. B., (2019), *Approaches series; Integrated Science for Senior High Schools*, 7th edition, pg. 600, Published by APPROACHERS (GHANA) Limited.

Peter A. & Henric A. B., (2011), *AKI- OLA series; Integrated Science for Senior High Schools*, 4th ed, printed and published in Ghana by AKI- OLA Publications.

Schmidt, D. L., Saigo, B.W., Stepans, J. I. (2006). *Conceptual Change Model*: The CCM Handbook. Saiwood Publications.

WASSCE/ WAEC Integrated Science Teaching Syllabus, (2010), pg. 35-36

Relevant Previous Knowledge: students have previous knowledge on force and effect of force on the objects.

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

4. define pressure
5. perform simple calculation on pressure
6. describe the effects and application of pressure in solids, liquids and gases

Teaching and Learning Materials:

Rectangular block of wood, a tall container with three holes at different heights, bicycle pump, water

Teacher- Learners' Activities

Introduction: teacher begins the lesson by giving students a series of questions (SMDT) on the lesson to test their preconception on the CCM pressure concept;

Activity one: teacher brainstorms students to bring out the meaning of pressure.

Activity two: teacher discusses with students the pressure exerted by solids assisting students to perform some calculations on pressure.

Activity three: teacher demonstrates pressure in liquids to students by using a tall container with three holes at different heights and filling it with water from the tap.

Activity four: teacher explains the transmission of pressure or pressure in gas to students by using a bicycle pump to demonstrate.

Activity five: teacher discusses with students some applications of pressure.

CORE POINTS

- Administration of SMDT on CCM Pressure Concept

Definition of pressure

- Pressure is defined as the force per unit area of a body. Mathematically, pressure= $force/area$

Pressure in solids

- Pressure in solids is affected by the following factors;
  1. magnitude of force
  2. area in contact.
- Pressure in solids can be calculated from the formula; $P = F/A$, where P is the pressure, F is the magnitude of the force and A is the area in contact.

Pressure in liquids

- Pressure in liquids is obtained by the product of the depth of the liquid, the density of the liquid and the acceleration due to gravity acting on the surface of the liquid. Thus $P = \rho gh$ where P is pressure, ρ is density of the liquid, g is acceleration due to gravity and h is the depth of the liquid.

Pressure in gas

Pressure in gas or atmospheric pressure is the pressure exerted by air in the atmosphere. Atmospheric pressure acts in all directions and is affected by altitude. The higher the altitude, the smaller the atmospheric pressure and vice versa.

Conclusion: teacher brings the lesson to an end by giving students the chance to ask questions on the concept that challenges their prior knowledge or assumptions and helps them to address it.

The teacher also assigns a task or exercise (an evaluation) for the students to complete in order to test the lesson objectives.

Evaluation

1. Define pressure
2. Give reasons why cutting and piercing tools are made sharp.
3. A regular concrete block weighing 5kg has an area of $0.016m^2$. calculate the pressure the block will exert on the ground. [$g = 10ms^{-2}$].

APPENDIX B

Students Misconceptions Diagnostic Test CCM FORCE CONCEPT- lesson one

Choose the most appropriate answer (option) from the list of options provided for questions . Answer all questions on the question paper. Total = 6 marks

1. When a force is applied to a body, it may result in the following changes except for a change in

   A. speed of the motion of the body

   B. shape of the body

   C. direction of motion of the body

   D. mass of the body

2. Bodies are weightless in space because

   A. the acceleration due to gravity of the earth balances that of the sun

   B. of the absence of air

   C. of the absence of the force of gravity

   D. the weight of the body exactly balances the force of gravity

3. The frictional force between two bodies depends on the

   A. area of the surface in contact

   B. speed at which the bodies are moving

   C. nature of the surfaces of the bodies in contact

   D. moment of the bodies in contact

4. When a balloon is pushed into the water and released, what type of force brings it back to the surface of the water.

   A. Tension B. friction C. upthrust D. gravity

5. Do forces act on object at rest? If yes, identify the type(s) of force(s) acting on **Hanging pen** when at rest. **2mark**

Students Misconceptions Diagnostic Test CCM FORCE CONCEPT- lesson 2

Choose the most appropriate answer (option) from the list of options provided for questions . Answer all questions on the question paper. Total = 6marks

1. When a hydrometer floats in a liquid, it means that the

   A. weight of the liquid displaced is equal to the weight of the hydrometer.

   B. density of the hydrometer is greater than the density of the liquid.

   C. upthrust on the hydrometer is less than the volume of the hydrometer.

   D. volume of the portion of the hydrometer in the liquid is equal to the volume of the liquid displaced.

2. A submarine at a depth in the sea will resurface when

   A. the pressure on it is decreased

   B. the speed is reduced

   C. water is pumped out of it

   D. air is pumped out of it

3. Ships sink more easily in freshwater than in seawater because

   A. currents are absent in freshwater

   B. there are much more organisms in seawater

   C. sea water is denser

   D. sea water does not flow

4. When the weight of the fluid displaced is less than the weight of the solid body immersed in it then the body

A. floats
B. sinks in the fluid
C. will be rotating
D. will be half immersed in the fluid

5. Consider a ball on top of a table. Since the ball stays at rest (meaning it does not change its motion) can we say that there is no force acting on it? Explain your response. **2marks**

Students Misconceptions Diagnostic Test CCM MOTION CONCEPT- lesson 3

Choose the most appropriate answer (option) from the list of options provided for questions . Answer all questions on the question paper Total = 5 marks

1. Which of the following statement is correct?

   I. inertia and momentum are identical.

   II. the unit of inertia in kilogram metre per second.

   III. momentum is the product of mass and velocity.

   A. I only B. II only C. III only D. I and II only
2. A boy pushes a stationary car. The car moves reluctantly. This is possible because the car has

   A. a momentum B. a moment C. an inertia D. an impulse
3. Distance travelled in a specific direction is known as

   A. acceleration B. displacement C. speed D. velocity
4. Why is it important to wear a seat belt when you are in a moving vehicle? **2marks**

Students Misconceptions Diagnostic Test CCM MOTION CONCEPT- lesson 4

Choose the most appropriate answer (option) from the list of options provided for questions . Answer all questions on the question paper Total = 6 marks

1. The centre of gravity of a body is the point

   A. where its original weight acts.

   B. where the body can be stable.

   C. where the total mass of the body acts.

   D. which divides the body into two equal parts
2. Acrobats walking on ropes usually keep their hands stretched sideways to

   A. maintain their centre of gravity perpendicular to the rope

B. increase the surface area of their bodies

C. maintain a narrow base on the rope

D. decrease their weight

3. A wooden block is placed on an inclined plane which is raised gradually. The block falls off only when the centre of gravity

A. is low B. being high C. is within the base D. falls outside its base

4. To increase the stability of a body, the

A. body must be made heavier

B. height and base length of the body must be increase

C. base length must be increase

D. height of the body must be reduced and the base length must be increase

5. Why is it dangerous to load the top carriers of vehicles heavy? **2marks**

Students Misconceptions Diagnostic Test CCM PRESSURE CONCEPT- lesson 5

Choose the most appropriate answer (option) from the list of options provided for questions . Answer all questions on the question paper. Total = **7marks**

1. Which of the following device does not employ the application of pressure?

A. Hydraulic press

B. Siphon

C. Bicycle pump

D. Hydrometer

2. The pressure of an object can be calculated from the formula

A. $mass \times$ acceleration

B. force/area

C. $area$/force

D. force $\times$ area.

3. Which of the following statements about pressure is not correct? Pressure

A. Increases with an increase with surface

B. Decreases with an increase in surface area

C. Increases with a decrease in surface area

D. Increases with an increase in applied force

4. A wind is caused due to the…………

A. force acting on it

B. Difference in height

C. Pressure difference

D. None of these

5. A small hole is made at the bottom of a vessel. The speed with which the water comes out of the hole depends on the

A. Density B. volume C. mass D. height

6. Give reasons why cutting and piercing tools are made sharp. **2marks**

APPENDIX C

Science Performance Test (SPT)

Instructions: The questions consist of two sections; section A and B. section A consists of multiple-choice questions whilst section B consist of short answer questions. Choose the most appropriate answer (option) from the list of options provided for question 1 to 20 in section A and write your answer for the questions in section B. questions in section A carries 20 marks whilst section B carries 10 marks. Answer all questions in the answer booklet provided.

Section A (20 marks) **Time: 50mins**

1. Which of the following device does not employ the application of pressure?
   A. Hydraulic press
   B. Siphon
   C. Bicycle pump
   D. Hydrometer
2. When a force is applied to a body, it may result in the following changes except for a change in
   A. speed of the motion of the body
   B. shape of the body
   C. direction of motion of the body
   D. mass of the body
3. Which of the following statement is correct?

   I. inertia and momentum are identical.

   II. the unit of inertia in kilogram metre per second.

   III. momentum is the product of mass and velocity.

   A. I only B. II only C. III only D. I and II only
4. When a balloon is pushed into the water and released, what type of force brings it back to the surface of the water.
   A. Tension B. friction C. upthrust D. gravity
5. The centre of gravity of a body is the point

A. where its original weight acts.
B. where the body can be stable.
C. where the total mass of the body acts.
D. which divides the body into two equal parts

6. Bodies are weightless in space because
   A. the acceleration due to gravity of the earth balances that of the sun
   B. of the absence of air
   C. of the absence of the force of gravity
   D. the weight of the body exactly balances the force of gravity
7. The pressure of an object can be calculated from the formula
   A. $mass \times$ acceleration
   B. force/area
   C. $area$/force
   D. force $\times$ area.
8. A boy pushes a stationary car. The car moves reluctantly. This is possible because the car has
   A. a momentum B. a moment C. an inertia D. an impulse
9. When a hydrometer floats in a liquid, it means that the
   A. Weight of the liquid displaced is equal to the weight of the hydrometer.
   B. Density of the hydrometer is greater than the density of the liquid.
   C. Upthrust on the hydrometer is less than the volume of the hydrometer.
   D. Volume of the portion of the hydrometer in the liquid is equal to the volume of the liquid displaced.
10. A small hole is made at the bottom of a vessel. The speed with which the water comes out of the hole depends on the
    A. Density B. volume C. mass D. height
11. A submarine at a depth in the sea will resurface when
    A. the pressure on it is decreased
    B. the speed is reduced
    C. water is pumped out of it
    D. air is pumped out of it
12. Distance travelled in a specific direction is known as
    A. acceleration B. displacement C. speed D. velocity

13. The frictional force between two bodies depends on the
    A. area of the surface in contact
    B. speed at which the bodies are moving
    C. nature of the surfaces of the bodies in contact
    D. moment of the bodies in contact
14. Which of the following statements about pressure is not correct? Pressure
    A. Increases with an increase with surface
    B. Decreases with an increase in surface area
    C. Increases with a decrease in surface area
    D. Increases with an increase in applied force
15. Ships sink more easily in freshwater than in seawater because
    A. currents are absent in freshwater
    B. there are much more organisms in seawater
    C. sea water is denser
    D. sea water does not flow
16. Acrobats walking on ropes usually keep their hands stretched sideways to
    A. Maintain their centre of gravity perpendicular to the rope
    B. Increase the surface area of their bodies
    C. Maintain a narrow base on the rope
    D. Decrease their weight
17. For a body to float in a liquid, it must displace a quantity of the fluid to its
    A. mass B. surface area C. volume D. weight
18. A wind is caused due to the…………
    A. force acting on it
    B. Difference in height
    C. Pressure difference
    D. None of these
19. A wooden block is placed on an inclined plane which is raised gradually. The block falls off only when the centre of gravity
    A. is low B. is high C. is within the base D. falls outside its base

20. Passengers in a moving car are jerked forward when the car suddenly stops. This is known as
    A. law of conservation of energy
    B. law of conservation of momentum
    C. law of inertia
    D. law of action and reaction

SECTION B **10 Marks**

21. Consider a ball on top of a table. Since the ball stays at rest (meaning it does not change its motion) can we say that there is no force acting on it? Explain your response. 2marks
22. Identify the type(s) of force(s) acting on **Hanging pen** when at rest? 2marks
23. Why is it important to wear a seat belt when you are in a moving vehicle? 2marks
24. Why is it dangerous to load the top carriers of vehicles heavy? 2marks
25. Give reasons why cutting and piercing tools are made sharp. 2marks

APPENDIX D

INTERVIEW QUESTIONS ON THE USED OF CONCEPTUAL CHANGE MODEL AS A TEACHING STRATEGY

1. Did you identify any misconception you have on the concept force, motion and pressure when taught with the conceptual change model approach?
2. Has the conceptual change lesson improved your understanding on the force, motion and pressure concepts? How has it addressed your identified misconceptions?
3. What was your expectation in terms of performance in the Science Performance Test after the intervention? Did you receive total, partial or no remediation of misconception after the conceptual change lessons?
4. Did your instructor consider individual needs and interests when using the conceptual change model as an instruction?
5. How was your feeling when participating in the lesson; force, motion and pressure when taught through the conceptual change model?
6. Did your instructor embrace your interest when teaching through the conceptual change model approach?
7. If you are given the chance, would you choose to be taught through the conceptual change model instructions mostly?